Access DB# 151954

SEARCH REQUEST FORM

Scientific and Technical Information Center

Requester's Full Name: Alan Diamond Examiner # : 70817 Date: 4/28/05
Art Unit: 1753 Phone Number ~~30~~ 571-272-1338 Serial Number: 09/885,319
Mail Box and Bldg/Room Location: REM 8-C75 Results Format Preferred (circle): PAPER DISK E-MAIL

If more than one search is submitted, please prioritize searches in order of need.

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Please provide a detailed statement of the search topic, and describe as specifically as possible the subject matter to be searched. Include the elected species or structures, keywords, synonyms, acronyms, and registry numbers, and combine with the concept or utility of the invention. Define any terms that may have a special meaning. Give examples or relevant citations, authors, etc, if known. Please attach a copy of the cover sheet, pertinent claims, and abstract.

Title of Invention: An Apparatus and Method for optimizing the efficiency of germanium

Inventors (please provide full names): Mark Stan; Nein Yi Li; Frank Spadafora; Hong Q. Hou
Paul Sharps; Navid Fateni

Earliest Priority Filing Date: ______

***For Sequence Searches Only* Please include all pertinent information (parent, child, divisional, or issued patent numbers) along with the appropriate serial number.**

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STAFF USE ONLY		Type of Search		Vendors and cost where applicable	
Searcher:	EJ	NA Sequence (#)		STN	$331.82
Searcher Phone #:		AA Sequence (#)		Dialog	
Searcher Location:		Structure (#)	✓ (1)	Questel/Orbit	
Date Searcher Picked Up:		Bibliographic	✓ (and)	Dr.Link	
Date Completed:	5-4-05	Litigation		Lexis/Nexis	
Searcher Prep & Review Time:	5	Fulltext		Sequence Systems	
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Online Time:	60	Other		Other (specify)	

PTO-1590 (8-01)

Access DB# 151954

SEARCH REQUEST FØRM

Scientific and Technical Information Center

Requester's Full Name: Alan Diamond Examiner # : 70817 Date: 4/28/05
Art Unit: 1753 Phone Number ~~30~~ 571-272-1338 Serial Number: 09/885,319
Mail Box and Bldg/Room Location: REM 8-C75 Results Format Preferred (circle): PAPER DISK E-MAIL

If more than one search is submitted, please prioritize searches in order of need.

****

Please provide a detailed statement of the search topic, and describe as specifically as possible the subject matter to be searched. Include the elected species or structures, keywords, synonyms, acronyms, and registry numbers, and combine with the concept or utility of the invention. Define any terms that may have a special meaning. Give examples or relevant citations, authors, etc, if known. Please attach a copy of the cover sheet, pertinent claims, and abstract.

Title of Invention: An Apparatus and Method for optimizing the efficiency of germanium...

Inventors (please provide full names): Mark Stan; Nein Yi Li; Frank Spadafora; Hong Q. Hou
Paul Sharps; Navid Fateni

Earliest Priority Filing Date: ______________________

***For Sequence Searches Only* Please include all pertinent information (parent, child, divisional, or issued patent numbers) along with the appropriate serial number.**

(new) A solar cell comprising:

a germanium substrate; and

a layer of material including In and P disposed directly on the germanium substrate.

(new) A solar cell as defined in claim 54, wherein the layer of material is InGaP.

****

STAFF USE ONLY	**Type of Search**	**Vendors and cost where applicable**
Searcher:	NA Sequence (#)	STN
Searcher Phone #:	AA Sequence (#)	Dialog
Searcher Location:	Structure (#)	Questel/Orbit
Date Searcher Picked Up:	Bibliographic	Dr.Link
Date Completed:	Litigation	Lexis/Nexis
Searcher Prep & Review Time:	Fulltext	Sequence Systems
Clerical Prep Time:	Patent Family	WWW/Internet
Online Time:	Other	Other (specify)

PTO-1590 (8-01)

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=> display history full l1-


     FILE 'REGISTRY'
L1          4330 SEA (IN(L)P)/ELS
L2           206 SEA L1 (L) GA/ELS (L) 3/ELC.SUB

     FILE 'HCA'
L3         49490 SEA (SOLAR? OR SUN OR PHOTOELEC? OR PHOTOGALVANI?)(2A)(CE
                 LL OR CELLS)
L4          7475 SEA L2
L5          3968 SEA INGAP OR GAINP OR PINGA OR PGAIN OR INPGA OR GAPIN
L6           466 SEA L3 AND (L4 OR L5)

     FILE 'LCA'
L7         10452 SEA (SUBSTRAT? OR SURFACE? OR BASE# OR SUBSTRUCT? OR
                 UNDERSTRUCT? OR UNDERLAY? OR FOUNDATION? OR PANE? OR
                 DISK? OR DISC# OR WAFER?)/BI,AB

     FILE 'REGISTRY'
                 E GERMANIUM/CN
L8             1 SEA GERMANIUM/CN

     FILE 'HCA'
L9         11909 SEA (L8 OR GERMANIUM# OR GE)(2A)(SUBSTRAT? OR SURFACE?
                 OR BASE# OR SUBSTRUCT? OR UNDERSTRUCT? OR UNDERLAY? OR
                 FOUNDATION? OR PANE? OR DISK? OR DISC# OR WAFER?)
L10          310 SEA L3 AND L9
L11           53 SEA L10 AND (L4 OR L5)
L12           47 SEA L11 AND L4
L13           25 SEA L11 AND L5
L14           19 SEA L12 AND L13
L15           34 SEA (L11 OR L12 OR L13) NOT L14
L16        68220 SEA L8
L17           42 SEA L11 AND L16
L18           34 SEA (L11 OR L12 OR L13 OR L17) NOT L14
                 E COATINGS/CV
L19        43471 SEA "COATING(S)"/CV OR COATINGS/CV
                 E COATING MATERIALS/CV
L20       259846 SEA "COATING MATERIALS"/CV
                 E COATING PROCESS/CV
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L21      118445 SEA "COATING PROCESS"/CV
L22           1 SEA L11 AND (L19 OR L20 OR L21)
L23           1 SEA L6 AND (L19 OR L20 OR L21)
L24          19 SEA L14 OR L22 OR L23
L25          34 SEA L18 NOT L24
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=> file hca
FILE 'HCA'

=> d l24 1-19 cbib abs hitstr hitind

L24 ANSWER 1 OF 19 HCA COPYRIGHT 2005 ACS on STN
142:300899 1.6/1.1 eV metamorphic **GaInP**/GaInAs **solar cells** grown by MOVPE on Ge. Fetzer, C. M.; Yoon, H.; King, R. R.; Law, D. C.; Isshiki, T. D.; Karam, N. H. (Spectrolab Engineering Inc., Sylmar, CA, 91342-5373, USA). Journal of Crystal Growth, 276(1-2), 48-56 (English) 2005. CODEN: JCRGAE. ISSN: 0022-0248. Publisher: Elsevier B.V..

AB This paper focuses on the metalorg. vapor phase epitaxy (MOVPE) growth of two-junction **solar cells** where epitaxial Ga0.29In0.71P top and Ga0.77In0.23As bottom subcells are grown lattice-mismatched on a **Ge substrate.** Single-junction metamorphic devices with Ga0.77In0.23As are grown on 100-mm diam. (001) **Ge substrates.** Layers are obsd. to be fully relaxed by high-resoln. x-ray diffraction. Threading dislocation densities of 3.1 .times. 106 cm-2 are measured. Single-junction devices in the 1.1-eV materials demonstrate near 100% internal quantum efficiency above the band gap and an open-circuit voltage comparable to world-record silicon photovoltaic devices. The presence and strength of CuPtB ordering is explored in controlling the band gap of the Ga0.29In0.71P top subcell devices between 1.647 and 1.593 eV. An order parameter of 0.28 is measured by x-ray measurement of the forbidden 1/2 (115) reflection for the low-band gap material. The presence of low-resistance shunt pathways is obsd. as the present obstacle to reaching the potential efficiency of 30% for these metamorphic dual-junction devices.

IT **219652-96-7**, Gallium indium phosphide (Ga0.29In0.71P)
(fabrication and testing of 1.6/1.1 eV metamorphic gallium indium phosphide/gallium indium arsenide **solar cells** grown by metalorg. vapor phase epitaxy on germanium)

RN 219652-96-7 HCA
CN Gallium indium phosphide (Ga0.29In0.71P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.71	7440-74-6
Ga	0.29	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium gallium phosphide metamorphic **solar cell**; gallium indium arsenide metamorphic **solar cell**; **solar cell** metamorphic growth **germanium substrate**
IT Metalorganic vapor phase epitaxy
Solar cells
(fabrication and testing of 1.6/1.1 eV metamorphic gallium indium phosphide/gallium indium arsenide **solar cells** grown by metalorg. vapor phase epitaxy on germanium)
IT 7440-56-4, Germanium, uses 109301-90-8, Gallium indium arsenide (Ga0.77In0.23As) **219652-96-7**, Gallium indium phosphide (Ga0.29In0.71P)
(fabrication and testing of 1.6/1.1 eV metamorphic gallium indium phosphide/gallium indium arsenide **solar cells** grown by metalorg. vapor phase epitaxy on germanium)

L24 ANSWER 2 OF 19 HCA COPYRIGHT 2005 ACS on STN
142:180400 Structuring of dual **solar cells** using nano-growth molecular beam epitaxy. Lee, Yong Tak; Song, Jin Dong (Kwangju Institute of Science and Technology, S. Korea). Repub. Korean Kongkae Taeho Kongbo KR 2003002105 A 20030108, No pp. given (Korean). CODEN: KRXXA7. APPLICATION: KR 2001-38845 20010630.
AB This dual **solar cell** has an absorbing layer adapted to the solar spectrum and it is made by MBE using short-period super-elastic growth. A p-type substrate is formed with a p-type contact layer and a GaAs or **Ge substrate.** A lower energy absorbing layer is formed with a **GaInP**(p) BSF, a GaAs(p) base, a GaAs(n) emitter, and a **GaInP**(n) window. A **GaInP**(n) emitter has a nano column structure of **GaInP**(p) BSF. A **GaInP**(n) base has a nano column structure. An upper energy absorbing layer is formed with an AlInP(n) window. The upper energy absorbing layer is formed on a base and an emitter by using a short-period super-elastic growth method.
IT **106312-00-9**, Gallium indium phosphide
(in structuring of dual **solar cells** using nano-growth mol. beam epitaxy)
RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM H01L031-04
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST dual **solar cell** structure nano growth mol beam
epitaxy
IT Molecular beam epitaxy
Nanostructures
Solar cells
(structuring of dual **solar cells** using
nano-growth mol. beam epitaxy)
IT 1303-00-0, Gallium arsenide (GaAs), uses 7440-56-4, Germanium,
uses **106312-00-9**, Gallium indium phosphide 107121-39-1,
Aluminum indium phosphide
(in structuring of dual **solar cells** using
nano-growth mol. beam epitaxy)

L24 ANSWER 3 OF 19 HCA
141:352724 Multijunction photovoltaic cell grown on high-miscut-angle
substrate. King, Richard R.; Ermer, James H.; Colter, Peter C.;
Fetzer, Chris (The Boeing Company, USA). U.S. Pat. Appl. Publ. US
2004200523 A1 20041014, 21 pp. (English). CODEN: USXXCO.
APPLICATION: US 2003-413906 20030414.
AB The present invention provides a photovoltaic cell comprising a
GaInP subcell comprising a disordered group-III sublattice,
a Ga(In)As subcell disposed below the **GaInP** subcell, and a
Ge substrate disposed below the Ga(In)As subcell
comprising a surface misoriented from a (100) plane by an angle from
about 8 degrees to about 40 degrees toward a nearest (111) plane.
IT **106312-00-9**, Gallium indium phosphide ((Ga,In)P)
(multijunction photovoltaic cell grown on high-miscut-angle
substrate)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM H01L031-00
INCL 136262000; 136252000
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar** photovoltaic **cell** high miscut angle
substrate
IT Optoelectronic semiconductor devices
Semiconductor materials
Tandem **solar cells**
Tunnel junctions
(multijunction photovoltaic cell grown on high-miscut-angle
substrate)
IT 409-21-2, Sic, uses 1303-00-0, Gallium arsenide (GaAs), uses
1306-25-8, Cadmium telluride (CdTe), uses 1312-41-0 1314-13-2,
Zinc oxide (ZnO), uses 1315-09-9, Zinc selenide (ZnSe)
1315-11-3, Zinc telluride (ZnTe) 1344-28-1, Alumina, uses
7440-21-3, Silicon, uses 7440-56-4, Germanium, uses 11085-97-5,
Aluminum gallium arsenide phosphide ((Al,Ga)(As,P)) 11148-21-3
12626-36-7, Cadmium selenide sulfide (Cd(Se,S)) 12645-36-2,
Gallium indium arsenide phosphide ((Ga,In)(As,P)) 20859-73-8,
Aluminum phosphide (AlP) 22831-42-1, Aluminum arsenide (AlAs)
24304-00-5, Aluminum nitride (AlN) 25617-97-4, Gallium nitride
(GaN) 25617-98-5, Indium nitride (InN) 37382-15-3, Aluminum
gallium arsenide ((Al,Ga)As) 59989-74-1, Zinc selenide sulfide
(Zn(Se,S)) 60953-19-7, Gallium arsenide phosphide (Ga(As,P))
106070-23-9, Aluminum indium arsenide ((Al,In)As) 106070-25-1,
Gallium indium arsenide ((Ga,In)As) 106097-44-3, Aluminum gallium
nitride ((Al,Ga)N) **106312-00-9**, Gallium indium phosphide
((Ga,In)P) 106389-74-6, Cadmium zinc telluride ((Cd,Zn)Te)
106603-89-8, Antimony gallium arsenide ((Sb,As)Ga) 106603-90-1,
Indium arsenide phosphide (In(As,P)) 106604-01-7, Gallium indium
antimonide gainsb 107102-89-6, Aluminum gallium indium phosphide
((Al,Ga,In)P) 107121-39-1, Aluminum indium phosphide ((Al,In)P)
107404-26-2, Aluminum indium arsenide phosphide ((Al,In)(As,P))
107404-28-4, Aluminum Indium antimonide phosphide 107874-73-7,
Cadmium zinc selenide ((Cd,Zn)Se) 108398-96-5, Cadmium zinc
selenide telluride ((Cd,Zn)(Se,Te)) 108821-49-4, Zinc selenide
telluride (Zn(Se,Te)) 110758-38-8 120994-22-1, Aluminum indium
nitride ((Al,In)N) 120994-23-2, Gallium indium nitride ((Ga,In)N)
124504-34-3, Aluminum antimony gallium arsenide ((Al,Sb,Ga)As)
127275-97-2 127575-65-9, Aluminum gallium indium nitride
((Al,Ga,In)N) 144972-86-1, Copper gallium indium selenide
156739-92-3, Gallium indium arsenide nitride ((Ga,In)(As,N))
173018-34-3, Gallium indium nitride phosphide ((Ga,In)(N,P))
176655-87-1, Copper gallium indium selenide sulfide 177715-13-8,
Copper gallium indium sulfide 190247-89-3, Antimony gallium indium
phosphide 219737-63-0, Aluminum gallium indium arsenide nitride
((Al,Ga,In)(As,N)) 317817-96-2, Gallium indium antimonide arsenide
nitride 424824-02-2, Aluminum gallium indium arsenide

((Al,Ga)InAs) 647839-30-3, Aluminum antimony indium phosphide 666180-19-4, Antimony gallium arsenide boride (SbGaAsB) 677798-46-8, Gallium indium silver selenide ((Ga,In,Ag)Se) 775318-30-4, Copper gallium indium telluride 775318-31-5, Gallium indium silver telluride 775318-32-6, Copper gallium indium silver selenide 775318-33-7
(multijunction photovoltaic cell grown on high-miscut-angle substrate)

L24 ANSWER 4 OF 19 HCA COPYRIGHT 2005 ACS on STN
140:114148 High-efficiency metamorphic **GaInP**/GaInAs/Ge **solar cells** grown by MOVPE. Fetzer, C. M.; King, R. R.; Colter, P. C.; Edmondson, K. M.; Law, D. C.; Stavrides, A. P.; Yoon, H.; Ermer, J. H.; Romero, M. J.; Karam, N. H. (Spectrolab, Inc., Sylmar, CA, 91342-5373, USA). Journal of Crystal Growth, 261(2-3), 341-348 (English) 2004. CODEN: JCRGAE. ISSN: 0022-0248. Publisher: Elsevier.

AB This paper focuses on the metalorg. vapor-phase epitaxy (MOVPE) growth of three-junction **solar cells** where the epitaxial Ga0.44In0.56P top and Ga0.92In0.08As middle subcells are grown lattice-mismatched on a **Ge substrate.** Single-junction metamorphic devices with 8%- and 12%-In, GaInAs are grown on 100 mm diam. (001) **Ge substrates** and evaluated in comparison to approx. lattice-matched GaAs and Ga0.99In0.01As subcells. Layers are obsd. to be nearly 100% relaxed by high-resoln. x-ray diffraction. Threading dislocation densities of .apprx.2 .times. 105 cm-2 in the 8%-In layers are obsd. by electron beam induced current and cathodoluminescence. Single-junction devices show a const. offset between open-circuit voltage and bandgap of .apprx.380 mV. Building upon these results, three-junction metamorphic Ga0.44In0.56P/Ga0.92In0.08As/Ge **solar cells** are fabricated. Very high performances of small area devices are reported with 28.8% efficiency under the air-mass 0 spectrum and 31.3% efficiency under the air-mass 1.5G 1-sun terrestrial spectrum.

IT **124923-23-5**, Gallium indium phosphide (Ga0.44In0.56P)
(high-efficiency metamorphic gallium indium phosphide/gallium indium arsenide/germanium **solar cells** grown by metalorg. vapor-phase epitaxy)

RN 124923-23-5 HCA

CN Gallium indium phosphide (Ga0.44In0.56P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.56	7440-74-6
Ga	0.44	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium gallium phosphide metamorphic **solar cell**;
gallium indium arsenide metamorphic **solar cell**;
germanium metamorphic **solar cell**
IT **Solar cells**
(high-efficiency metamorphic gallium indium phosphide/gallium indium arsenide/germanium **solar cells** grown by metalorg. vapor-phase epitaxy)
IT 7440-56-4, Germanium, uses 107404-63-7, Gallium indium arsenide (Ga0.92In0.08As) **124923-23-5**, Gallium indium phosphide (Ga0.44In0.56P)
(high-efficiency metamorphic gallium indium phosphide/gallium indium arsenide/germanium **solar cells** grown by metalorg. vapor-phase epitaxy)

L24 ANSWER 5 OF 19 HCA COPYRIGHT 2005 ACS on STN
139:152230 Single junction **InGaP**/GaAs **solar cells** grown on Si substrates using SiGe buffer layers.
Ringel, S. A.; Carlin, J. A.; Andre, C. L.; Hudait, M. K.; Gonzalez, M.; Wilt, D. M.; Clark, E. B.; Jenkins, P.; Scheiman, D.; Allerman, A.; Fitzgerald, E. A.; Leitz, C. W. (Department of Electrical Engineering, The Ohio State University, Columbus, OH, 43210, USA). NASA Conference Publication, 2002-211831(17th Space Photovoltaic Research and Technology Conference, 2001), 160-177 (English) 2002. CODEN: NACPDX. ISSN: 0191-7811. Publisher: National Aeronautics and Space Administration.
AB Single-junction **InGaP**/GaAs **solar cells** displaying high efficiency and record high open-circuit voltage values have been grown by metalorg. chem. vapor deposition on Ge/graded SiGe/Si substrates. Open-circuit voltages as high as 980 mV under air-mass 0 (AM0) conditions have been verified to result from a single GaAs junction, with no evidence of Ge-related sub-cell photoresponse. Current AM0 efficiencies of close to 16% have been measured for a large no. of small area cells, whose performance is limited by non-fundamental current losses due to significant surface reflection resulting from >10% front surface metal coverage and wafer handling during the growth sequence for these prototype cells. It is shown that at the material quality currently achieved for GaAs grown on **Ge**/SiGe/Si **substrates**, namely a 10 ns minority carrier lifetime that results from complete elimination of anti-phase domains and maintaining a threading dislocation d. of .apprx.8 .times. 105 cm-2, 19-20% AM0 single-junction GaAs **solar cells** are imminent. Expts. show that the high performance is not degraded for larger area cells, with identical open-circuit voltages and higher short-circuit current (due to reduced front metal coverage) values being demonstrated, indicating that large area scaling is possible in the near term. Comparison to a simple model indicates that the voltage output of these GaAs on Si cells follows ideal behavior expected for lattice

mismatched devices, demonstrating that unaccounted for defects and issues that have plagued other methods to epitaxially integrate III-V cells with Si are resolved using SiGe buffers and proper GaAs nucleation methods. These early results already show the enormous and realistic potential of the virtual SiGe substrate approach for generating high-efficiency, lightwt. and strong III-V **solar cells.**

IT **106312-00-9**, Gallium indium phosphide
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** using silicon-**germanium** buffer layers)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST indium gallium phosphide **solar cell** germanium silicon buffer; gallium arsenide **solar cell** germanium silicon buffer

IT **Solar cells**
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** using silicon-**germanium** buffer layers)

IT 7440-56-4, Germanium, uses
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on germanium/graded silicon-**germanium**/silicon **substrates**)

IT 1303-00-0, Gallium arsenide, uses 7440-21-3, Silicon, uses 11148-21-3 **106312-00-9**, Gallium indium phosphide
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** using silicon-**germanium** buffer layers)

L24 ANSWER 6 OF 19 HCA COPYRIGHT 2005 ACS on STN

138:306847 Apparatus and method for optimizing the efficiency of a bypass diode in multijunction **solar cells.**
Sharps, Paul R.; Clevenger, Marvin Brad; Stan, Mark A. (Emcore Corp., USA). U.S. Pat. Appl. Publ. US 2003075215 A1 20030424, 10

pp. (English). CODEN: USXXCO. APPLICATION: US 2001-999598 20011024.

AB The invention relates to app. and method for optimizing the efficiency of a bypass diode in **solar cells.** In a preferred embodiment, a layer of TiAu is placed in an etch in a **solar cell** with a contact at a doped layer of GaAs. Elec. current is conducted through a diode and away from the main cell by passing through the contact point at the GaAs and traversing a lateral conduction layer. These means of activating, or "turning on" the diode, and passing the current through the circuit results in greater efficiencies than in prior art devices. The diode is created during the manuf. of the other layers of the cell and does not require addnl. manufg.

IT **106312-00-9**, Gallium indium phosphide **gainp**
(app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4, Germanium**, uses
(**substrate**; app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L031-00

INCL 136255000; 136249000; 136262000

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST optimization efficiency bypass diode multijunction **solar cell**

IT Schottky contacts
Tandem **solar cells**
(app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

IT Diodes
(bypass; app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

IT 1303-00-0, Gallium arsenide (GaAs), uses 7440-32-6, Titanium, uses

7440-57-5, Gold, uses 106070-25-1, Gallium indium arsenide gainas
106312-00-9, Gallium indium phosphide **gainp**
(app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

IT **7440-56-4**, **Germanium**, uses
(**substrate**; app. and method for optimizing efficiency of bypass diode in multijunction **solar cells**)

L24 ANSWER 7 OF 19 HCA COPYRIGHT 2005 ACS on STN
138:156182 Single-junction **InGaP**/GaAs **solar cells** grown on Si substrates with SiGe buffer layers.
Ringel, S. A.; Carlin, J. A.; Andre, C. L.; Hudait, M. K.; Gonzalez, M.; Wilt, D. M.; Clark, E. B.; Jenkins, P.; Scheiman, D.; Allerman, A.; Fitzgerald, E. A.; Leitz, C. W. (Department of Electrical Engineering, The Ohio State University, Columbus, OH, 43210, USA). Progress in Photovoltaics, 10(6), 417-426 (English) 2002. CODEN: PPHOED. ISSN: 1062-7995. Publisher: John Wiley & Sons Ltd..

AB Single-junction **InGaP**/GaAs **solar cells** displaying high efficiency and record high open-circuit voltage values have been grown by metalorg. chem. vapor deposition on Ge/graded SiGe/Si substrates. Open-circuit voltages of 980 mV under air-mass 0 (AM0) conditions have been verified to result from a single GaAs junction, with no evidence of Ge-related sub-cell photoresponse. AM0 efficiencies close to 16% have been measured for a large no. of small-area cells, the performance of which is limited by non-fundamental current losses due to significant surface reflection resulting from >10% front-surface metal coverage and wafer handling during the growth sequence for these prototype cells. It is shown that at the material quality currently achieved for GaAs grown on **Ge**/SiGe/Si **substrates**, namely a 10 ns minority carrier lifetime that results from complete elimination of antiphase domains, and maintaining a threading dislocation d. of .apprx.8 .times. 105 cm-2, 19-20% AM0 single junction GaAs cells are imminent. Expts. show that the high performance is not degraded for larger-area cells, with identical open-circuit voltages and higher short-circuit current (due to reduced front metal coverage) values being demonstrated, indicating that large-area scaling is possible in the near term. Comparison with a simple model indicates that the voltage output of these GaAs-on-Si cells follows the ideal behavior expected for lattice-mismatched devices, demonstrating that unaccounted-for defects and issues that have plagued other methods to epitaxially integrate III-V cells with Si are resolved by using SiGe buffers and proper GaAs nucleation methods. These early results already show the enormous and realistic potential of the virtual SiGe substrate approach for generating high-efficiency, lightwt. and strong III-V **solar cells.**

IT **106312-00-9**, Gallium indium phosphide
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon

substrates with **germanium**-silicon buffer
layers)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium gallium phosphide **solar cell** silicon substrate; gallium arsenide **solar cell** silicon substrate; germanium silicon buffer layer **solar cell**
IT **Solar cells**
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** with **germanium**-silicon buffer layers)
IT 1303-00-0, Gallium arsenide, uses 7440-21-3, Silicon, uses 11148-21-3 **106312-00-9**, Gallium indium phosphide
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** with **germanium**-silicon buffer layers)
IT 7440-56-4, Germanium, uses
(performance of single-junction gallium indium phosphide/gallium arsenide **solar cells** grown on silicon **substrates** with **germanium**-silicon buffer layers and)

L24 ANSWER 8 OF 19 HCA COPYRIGHT 2005 ACS on STN
138:92604 Multijunction **solar cells** and novel structures for **solar cell** applications.
Yamaguchi, Masafumi (Toyota Technological Institute, Tempaku, Nagoya, 468-8511, Japan). Physica E: Low-Dimensional Systems & Nanostructures (Amsterdam, Netherlands), 14(1-2), 84-90 (English) 2002. CODEN: PELNFM. ISSN: 1386-9477. Publisher: Elsevier Science B.V..
AB A review. The present status of R&D program for super-high efficiency III-V compd. multi-junction **solar cells** in the New Sunshine Project in Japan is presented. As a result of **InGaP** top cell material quality improvement, development of optically and elec. low-loss double-heterostructure **InGaP** tunnel junction, photon and carrier confinements, and lattice matching between active cell layers and **substrate**,

InGaP/InGaAs/**Ge** monolithic cascade 3-junction cells with an efficiency of 31.7% at 1-sun AM1.5 and **InGaP** /GaAs//InGaAs mech. stacked 3-junction cells with the highest (world-record) efficiency of 33.3% at 1-sun AM1.5 have been realized. As an approach for low-cost and high-efficiency cells, better radiation resistance of GaAs thin-film **solar cells** with novel structures fabricated on Si substrates has also been demonstrated. Novel structures such as Bragg reflector and super-lattice structures are found to show a better initial cell performance and radiation resistance since those layers act as buffer layers to reduce dislocations, and act as a back-surface field and back-surface reflector layers.

IT **106312-00-9**, Gallium indium phosphide
(multijunction **solar cells** and novel structures for **solar cell** applications)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-0 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST review **solar cell** multijunction

IT Electron beams
(irradn.; multijunction **solar cells** and novel structures for **solar cell** applications)

IT **Solar cells**
Tandem **solar cells**
(multijunction **solar cells** and novel structures for **solar cell** applications)

IT Group IIIA element pnictides
(multijunction **solar cells** and novel structures for **solar cell** applications)

IT 12256-32-5, Gallium arsenide phosphide GaAs0.8P0.2 106070-25-1, Gallium indium arsenide **106312-00-9**, Gallium indium phosphide 107498-93-1, Gallium indium arsenide ga0.9in0.1as
(multijunction **solar cells** and novel structures for **solar cell** applications)

IT 1303-00-0, Gallium arsenide, uses 7440-21-3, Silicon, uses 7440-56-4, Germanium, uses 107121-39-1, Aluminum indium phosphide
(multijunction **solar cells** and novel structures for **solar cell** applications)

L24 ANSWER 9 OF 19 HCA

137:188314 Gallium nitride collector grid **solar cell**
. Bianchi, Maurice P. (TRW Inc., USA). U.S. US 6447938 B1 20020910, 8 pp., Cont.-in-part of U.S. 6,103,604. (English). CODEN: USXXAM. APPLICATION: US 2000-632323 20000804. PRIORITY: US 1997-798349 19970210.

AB The title **solar cell** comprises a transparent conductive coating (TCC) formed from gallium nitride GaN on a sapphire substrate. In order to account for the lattice mismatch between the GaN and the sapphire substrate, a nucleation layer is formed on the sapphire substrate. A mask, for example, SiO2, is formed on top of the nucleation layer with a plurality of openings. GaN is grown through the openings in the mask to form a lateral epitaxial overgrowth layer upon which defect-free GaN is grown. The lateral epitaxial overgrowth compensates for the lattice mismatch between the sapphire substrate and the GaN. The use of a sapphire substrate eliminates the need for a cover glass and also significantly reduces the cost of the TCC, since such sapphire substrates are about 1/7 the cost of **germanium substrates.** The TCC may then be disposed on a GaAs **solar cell.** In order to compensate for the lattice mismatches between the GaAs and the GaN, an **InGaP** may be disposed between the GaAs **solar cell** and the GaN TCC to compensate for the lattice mismatch between the GaN and the GaAs. In order to further compensate for the lattice mismatch between the GaN and **InGaP**, the interface may be formed as a superlattice or as a graded layer. Alternatively, the interface between the GaN and the **InGaP** may be formed by the offset method or by wafer fusion. The TCC, in accordance with the present invention, is able to compensate for the lattice mismatches at the interfaces of the TCC while eliminating the need for a cover glass and a relatively expensive **germanium substrate.**

IT **106312-00-9**, Gallium indium phosphide
(gallium nitride collector grid **solar cell**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM B32B009-00

INCL 428698000

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST **solar cell** gallium nitride collector grid

IT **Coating materials**
(elec. conductive, transparent; gallium nitride collector grid **solar cell**)
IT **Solar cells**
(gallium nitride collector grid **solar cell**)
IT 1303-00-0, Gallium arsenide (GaAs), uses **106312-00-9**, Gallium indium phosphide
(gallium nitride collector grid **solar cell**)
IT 24304-00-5, Aluminum nitride 25617-97-4, Gallium nitride gan
(gallium nitride collector grid **solar cell**)
IT 7631-86-9, Silica, uses
(mask; gallium nitride collector grid **solar cell**)
IT 1317-82-4, Sapphire
(substrate; gallium nitride collector grid **solar cell**)

L24 ANSWER 10 OF 19 HCA
136:282020 Apparatus and method for optimizing the efficiency of germanium junctions in multi-junction **solar cells**
. Stan, Mark A.; Li, Nein Y.; Spadafora, Frank A.; Hou, Hong Q.; Sharps, Paul R.; Fatemi, Navid S. (USA). U.S. Pat. Appl. Publ. US 20020040727 A1 20020411, 10 pp. (English). CODEN: USXXCO. APPLICATION: US 2001-885319 20010619. PRIORITY: US 2000-PV212552 20000620.
AB App. and Method are disclosed for optimizing the efficiency of Ge junctions in multijunction **solar cells.** In a preferred embodiment, an **InGaP** nucleation layer is disposed between the **Ge substrate** and the overlying dual-junction epilayers for controlling the diffusion depth of the n-doping in the germanium junction. Specifically, by acting as a diffusion barrier to As contained in the overlying epilayers and as a source of n-type dopant for forming the Ge junction, the nucleation layer enables the growth time and temp. in the epilayer device process to be minimized without compromising the integrity of the dual-junction epilayer structure. This in turn allows the arsenic diffusion into the **germanium substrate** to be optimally controlled by varying the thickness of the nucleation layer. An active germanium junction formed in accordance with the present invention has a typical diffused junction depth that is 1/5 to 1/2 of that achievable in prior art devices. Furthermore, triple-junction **solar cells** incorporating a shallow n-p germanium junction of the present invention can attain 1 sun AM0 efficiencies in excess of 26%.
IT **106312-00-9**, Gallium indium phosphide
(app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)
RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM H01L031-00
INCL 136255000
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 47, 76
ST **solar cell** germanium multijunction efficiency optimization
IT **Solar cells**
(app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)
IT Vapor deposition process
(metalorg.; app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)
IT Diffusion
(solid-state; app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)
IT 1303-00-0, Gallium arsenide, uses 7440-56-4, Germanium, uses **106312-00-9**, Gallium indium phosphide
(app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)
IT 7440-38-2, Arsenic, uses 7723-14-0, Phosphorus, uses
(dopant; app. and method for optimizing efficiency of germanium junctions in multijunction **solar cells**)

L24 ANSWER 11 OF 19 HCA COPYRIGHT 2005 ACS on STN
135:333311 III-V space **solar cells** on Si substrates using graded GeSi buffers. Ringel, S. A.; Carlin, J. A.; Leitz, C. W.; Currie, M.; Langdo, T.; Fitzgerald, E. A.; Bulsara, M.; Wilt, D. M.; Clark, E. V. (Dep. Electrical Eng., The Ohio State Univ., Columbus, OH, USA). European Photovoltaic Solar Energy Conference, Proceedings of the International Conference, 16th, Glasgow, United Kingdom, May 1-5, 2000, Volume 1, 939-944. Editor(s): Scheer, Hermann. James & James (Science Publishers) Ltd.: London, UK. (English) 2000. CODEN: 69BOEK.
AB Single junction AlGaAs/GaAs and **InGaP**/GaAs **solar cells** and test structures have been grown by mol. beam epitaxy (MBE) and metal-org. chem. vapor deposition (MOCVD), resp., on Si wafers coated with compositionally-graded GeSi buffers. The combination of controlled strain relaxation within the GeSi buffer

and monolayer-scale control of the III-V layer nucleation step is shown to reproducibly generate minority carrier lifetimes exceeding 10 ns within GaAs overlayers. The III-V layers are free of long-range antiphase domain disorder, with threading dislocation densities in the high 105 cm-2 range, consistent with the low residual dislocation d. in the Ge cap of the graded buffer structure. Single junction Ga/As cells grown by both MBE and MOCVD on the **Ge**/GeSi/Si **substrates** demonstrated record-high Voc values for GaAs cells grown on Si. Voc values for MOCVD-grown single junction **InGaP**/GaAs cells exceeded 970 mV (AM0) with fill factors of 0.79 prior to anti-reflection coating. Cell efficiencies are conservatively projected to be in excess of 18.5% under AM0 conditions once cell processing (ARC) is completed. Such cell performance demonstrates the potential and viability of graded GeSi buffers for the development of III-V cells on Si wafers.

IT **106312-00-9**, Gallium indium phosphide
(III-V space **solar cells** on Si substrates with graded GeSi buffers)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST silicon **solar cells** germanium silicide buffer

IT **Solar cells**
Space vehicles
(III-V space **solar cells** on Si substrates with graded GeSi buffers)

IT 1303-00-0, Gallium arsenide, processes 7440-21-3, Silicon, processes 11148-21-3 37382-15-3, Aluminum gallium arsenide ((Al,Ga)As) **106312-00-9**, Gallium indium phosphide
(III-V space **solar cells** on Si substrates with graded GeSi buffers)

L24 ANSWER 12 OF 19 HCA COPYRIGHT 2005 ACS on STN

135:197918 High-efficiency InGaAs-on-GaAs devices for monolithic multijunction **solar cell.** Hoffman, Richard W., Jr.; Fatemi, Navid S.; Stan, Mark A.; Jenkins, Phillip; Weizer, Victor G.; Scheiman, David A.; Brinker, David J. (Essential Research, Inc., Cleveland, OH, 44122, USA). European Commission, [Report] EUR, EUR 18656, 2nd World Conference on Photovoltaic Solar Energy Conversion, 1998, Volume III, 3604-3608 (English) 1998. CODEN: CECED9. ISSN: 1018-5593.

AB The demand for high-efficiency space **solar cells** increased significantly largely due to the expansion of the global com. communications satellite market. Power systems will continue to use high-efficiency cells, which can provide cost benefits to spacecraft when the total power system is considered. The traditional approach to high-efficiency, multijunction **solar cells** is to optimize the lattice match condition of all layers to the available **substrate**, typically **Ge**, and therefore compromise the band-gap combination for optimal performance. The reported approach was to emphasize the matching of optimal band-gap combinations and effectively accommodate the growth of the matched cell layers to a mismatched substrate. World record AM0 1-sun efficiencies were demonstrated using InGaAs cells, having a band-gap of 1.0-1.2 eV, grown on GaAs substrates. A lattice mismatch of .ltoreq.2.3% was effectively accommodated between the GaAs substrate and the active InGaAs cell. The level of performance required for a bottom cell in a 28-30% **InGaP**/InGaAs dual junction cell was demonstrated. The InGaAs cell having optimal band gap for use in 30-35% efficient triple- and quad-junction cells also was demonstrated.

IT **106312-00-9P**, Gallium indium phosphide
(high-efficiency indium gallium arsenide-on-gallium arsenide devices for monolithic multijunction **solar cell**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium arsenide multijunction **solar cell** ; phosphide indium gallium multijunction **solar cell**

IT **Solar cells**
(high-efficiency indium gallium arsenide-on-gallium arsenide devices for monolithic multijunction space)

IT 1303-00-0P, Gallium arsenide (GaAs), uses 106070-25-1P, Gallium indium arsenide **106312-00-9P**, Gallium indium phosphide
(high-efficiency indium gallium arsenide-on-gallium arsenide devices for monolithic multijunction **solar cell**)

L24 ANSWER 13 OF 19 HCA

135:183160 Multi-quantum well tandem **solar cells**

with efficiencies exceeding 30% AM0. Freundlich, A.; Serdiukova, I. (Space Vacuum Epitaxy Center, University of Houston, Houston, TX, 772014-5507, USA). European Commission, [Report] EUR, EUR 18656, 2nd World Conference on Photovoltaic Solar Energy Conversion, 1998, Volume III, 3707-3710 (English) 1998. CODEN: CECED9. ISSN: 1018-5593.

AB In this work a new two-terminal tandem **solar cell** concept is proposed. It is shown that the insertion of thin (few nm thick) narrow band-gap InGaAs quantum wells in the intrinsic i-region of the conventional p-i-n GaAs **solar cell** extends the photo-absorption of the conventional **GaInP** /GaAs tandem cell toward the IR. The approach provides a near-ideal spectral matching between top and bottom cells, while maintaining the entire structure lattice-matched to commonly used GaAs/ **Ge substrates.** Calcns. indicate that the current output resulting from the conversion of available below In0.5Ga0.5P band gap photons can be substantially increased by increasing the no. of wells in the intrinsic region leading to 1 sun air-mass 0 (AM0) efficiencies exceeding 31%.

IT **12776-63-5**, Gallium indium phosphide (GaInP2)
(design of multi-quantum well gallium indium phosphide/gallium arsenide tandem **solar cells** with efficiencies exceeding 30% air-mass 0)

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST quantum well tandem **solar cell** design; indium gallium arsenide quantum well tandem **solar cell**; gallium indium phosphide tandem **solar cell** quantum well

IT Quantum well devices
Tandem **solar cells**
(design of multi-quantum well gallium indium phosphide/gallium arsenide tandem **solar cells** with efficiencies exceeding 30% air-mass 0)

IT 1303-00-0, Gallium arsenide, uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(design of multi-quantum well gallium indium phosphide/gallium arsenide tandem **solar cells** with efficiencies exceeding 30% air-mass 0)

IT 107498-92-0, Gallium indium arsenide (Ga0.8In0.2As) 107498-93-1,

Gallium indium arsenide (Ga0.9In0.1As)
(quantum wells; design of multi-quantum well gallium indium phosphide/gallium arsenide tandem **solar cells** with efficiencies exceeding 30% air-mass 0)

L24 ANSWER 14 OF 19 HCA COPYRIGHT 2005 ACS on STN
135:124856 High efficiency GaAs-on-Si **solar cells** with high Voc using graded GeSi buffers. Carlin, J. A.; Hudait, M. K.; Ringel, S. A.; Wilt, D. M.; Clark, E. B.; Leitz, C. W.; Currie, M.; Langdo, T.; Fitzgerald, E. A. (Department of Electrical Engineering, The Ohio State University, Columbus, OH, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 28th, 1006-1011 (English) 2000. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB Single junction AlGaAs/GaAs and **InGaP**/GaAs **solar cells** and test structures have been grown by mol. beam epitaxy (MBE) and metalorg. chem. vapor deposition (MOCVD), resp., on Si wafers coated with compositionally-graded GeSi buffers. The combination of controlled strain relaxation within the GeSi buffer and monolayer-scale control of the Group III-V layer nucleation is shown to reproducibly generate minority carrier lifetimes exceeding 10 ns within GaAs overlayers. The III-V layers are free of long-range antiphase domain disorder, with threading dislocation densities in the high-105 cm-2 range, consistent with the low residual dislocation d. in the Ge cap of the graded buffer structure. Single junction GaAs cells grown by both MBE and MOCVD on the **Ge**/GeSi/Si **substrates** demonstrated high Voc values for GaAs cells grown on Si. Record Voc values for MOCVD-grown single junction **InGaP**/GaAs cells exceeded 980 mV (AMO) with fill factors of 0.79. Addnl., external quantum efficiency data indicates no degrdn. in carrier collection from GaAs homoepitaxial cells for current single-junction cell designs grown by MBE. Based on these results, cell efficiencies in excess of 18.5% under AMO conditions should be attainable with cell designs demonstrating state of the art Jsc values. Such cell performance demonstrates the potential and viability of graded GeSi buffers for the development of III-V cells on Si wafers.

IT **106312-00-9**, Gallium indium phosphide
(high efficiency GaAs-on-Si **solar cells** with high open-circuit voltage using graded GeSi buffers)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST gallium arsenide silicon **solar cell**
IT Molecular beam epitaxy
  Solar cells
   (high efficiency GaAs-on-Si **solar cells** with
   high open-circuit voltage using graded GeSi buffers)
IT Vapor deposition process
   (metalorg.; high efficiency GaAs-on-Si **solar**
   cells with high open-circuit voltage using graded GeSi
   buffers)
IT Electric current carriers
   (minority; high efficiency GaAs-on-Si **solar**
   cells with high open-circuit voltage using graded GeSi
   buffers)
IT 1303-00-0, Gallium arsenide, uses 37382-15-3, Aluminum gallium
   arsenide **106312-00-9**, Gallium indium phosphide
   (high efficiency GaAs-on-Si **solar cells** with
   high open-circuit voltage using graded GeSi buffers)
IT 7440-21-3, Silicon, uses 7440-56-4, Germanium, uses 11148-21-3
   (high efficiency GaAs-on-Si **solar cells** with
   high open-circuit voltage using graded GeSi buffers)

L24 ANSWER 15 OF 19 HCA
135:124850 Metamorphic **GaInP**/GaInAs/Ge **solar**
cells. King, R. R.; Haddad, M.; Isshiki, T.; Colter, P.;
Ermer, J.; Yoon, H.; Joslin, D. E.; Karam, N. H. (Spectrolab, Inc.,
Sylmar, CA, 91342, USA). Conference Record of the IEEE Photovoltaic
Specialists Conference, 28th, 982-985 (English) 2000. CODEN:
CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and
Electronics Engineers.

AB High-efficiency, metamorphic multijunction cells have been fabricated by growing **GaInP**/GaInAs subcells that are lattice-mismatched to an active **Ge substrate**, resulting in **GaInP**/GaInAs/Ge 3-junction (3J) cells. The efficiency dependence of this 3J cell on lattice-const. of the top two cells and on sublattice ordering in the **GaInP** top cell is presented. A variety of compn.-graded buffers have been explored through X-ray diffraction reciprocal space mapping to measure strain in the cell layers, and transmission electron microscopy to minimize misfit and threading dislocations. Quantum efficiency is measured for metamorphic 1.3-eV Ga0.92In0.08As cells and 1.75-eV Ga0.43In0.57P cells grown on a **Ge substrate**, as well as for the 3J cell based on 4%-In GaInAs. Three-junction Ga0.43In0.57P/Ga0.92In0.08As/Ge cells with 0.50% lattice-mismatch to the **Ge substrate** are measured to have AMO efficiency of 27.3% (0.1353 W/cm2, 28.degree.), similar to high-efficiency, conventional **GaInP**/GaAs/Ge 3-junction cells based on the GaAs lattice const.

IT **106312-00-9**, Gallium indium phosphide **gainp**
122162-61-2, Gallium indium phosphide Ga0.43In0.57P
(metamorphic **GaInP**/GaInAs/Ge **solar cells**)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

RN 122162-61-2 HCA
CN Gallium indium phosphide (Ga0.43In0.57P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.57	7440-74-6
Ga	0.43	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST **solar cell** metamorphic multijunction; gallium indium phosphide germanium **solar cell**
IT **Solar cells**
(metamorphic **GaInP**/GaInAs/Ge **solar cells**)
IT 7440-56-4, Germanium, uses 106070-25-1, Gallium indium arsenide gainas **106312-00-9**, Gallium indium phosphide **gainp**
107404-63-7, Gallium indium arsenide Ga0.92In0.08As
122162-61-2, Gallium indium phosphide Ga0.43In0.57P
(metamorphic **GaInP**/GaInAs/Ge **solar cells**)

L24 ANSWER 16 OF 19 HCA COPYRIGHT 2005 ACS on STN
135:124849 High efficiency **InGaP**/InGaAs tandem **solar cells** on **Ge substrates.** Takamoto, Tatsuya; Agui, Takaaki; Ikeda, Eiji; Kurita, Hiroshi (Japan Energy Corporation, Toda, 335, Japan). Conference Record of the IEEE Photovoltaic Specialists Conference, 28th, 976-981 (English) 2000. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.
AB Over 30% AM1.5G efficiency was achieved by adding a small quantity of indium into a GaAs bottom cell in the conventional tandem cell on a **Ge substrate.** Characteristics of InGaAs cells on Ge were investigated by varying In-compn. The max. efficiency

was obtained for the cell with 0.01 In-compn., which was lattice-matched to Ge and produced no misfit-dislocations. Relatively high efficiencies were obtained for the cells with In-compns. less than 0.1, which did not produce cracks but misfit-dislocations. **InGaP**/InxGa1-xAs tandem cells with In-compn. x between 0.01 and 0.07 demonstrated higher efficiency than the conventional **InGaP**/GaAs cells, that was attributed to an increase in photo-currents both in the top and bottom cells. Remarkably, an In0.49Ga0.51P/In0.01Ga0.99As tandem cell lattice-matched to Ge showed an improvement in Voc, which was attributed to an elimination of misfit-dislocations in thick GaAs layers. Also, those **InGaP**/InxGa1-xAs cells with low In-compns. were found to be favorable for improving efficiency of triple junction cells using Ge cells. Over 31% AM1.5G efficiency was demonstrated for the **InGaP**/InxGa1-xAs/Ge triple-junction cells with In-compn. x of 0.01 and 0.06, at present.

IT **106312-00-9**, Gallium indium phosphide **gainp**
106770-37-0, Gallium indium phosphide Ga0.51In0.49P
(high efficiency **InGaP**/InGaAs tandem **solar cells** on **Ge substrates**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

RN 106770-37-0 HCA

CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST **solar cell** gallium indium phosphide
germanium substrate

IT Tandem **solar cells**
(high efficiency **InGaP**/InGaAs tandem **solar cells** on **Ge substrates**)

IT 106070-25-1, Gallium indium arsenide gainas **106312-00-9**, Gallium indium phosphide **gainp** 106495-91-4, Gallium indium arsenide Ga0.99In0.01As **106770-37-0**, Gallium indium

phosphide Ga0.51In0.49P 111242-86-5, Gallium indium arsenide
Ga0.94In0.06As
(high efficiency **InGaP**/InGaAs tandem **solar cells** on **Ge substrates**)
IT 7440-56-4, Germanium, uses
(high efficiency **InGaP**/InGaAs tandem **solar cells** on **Ge substrates**)

L24 ANSWER 17 OF 19 HCA COPYRIGHT 2005 ACS on STN
134:88730 High-efficiency **InGaP**/In0.01Ga0.99As tandem **solar cells** lattice-matched to **Ge substrates.** Takamoto, T.; Agui, T.; Ikeda, E.; Kurita, H. (Central R&D Laboratory, Japan Energy Corporation, Saitama, Toda-shi, Niizo-Minami, 335-8502, Japan). Solar Energy Materials and Solar Cells, 66(1-4), 511-516 (English) 2001. CODEN: SEMCEQ. ISSN: 0927-0248. Publisher: Elsevier Science B.V..
AB Conversion efficiency (air-mass 1.5G) of >30% was achieved by adding a small quantity of indium into a GaAs bottom cell in the conventional tandem **solar cell** on **Ge substrate.** It was found that the lattice mismatch between GaAs and Ge caused misfit dislocations in thick GaAs layers and reduced the open-circuit voltage of the cell. In0.49Ga0.51P/In0.01Ga0.99As tandem cell lattice-matched to Ge showed a great improvement in efficiency, which was attributed to an increase in the open-circuit voltage of the bottom cell and increases in the photocurrents both in the top and bottom cells due to redns. in band-gap energy.
IT **106770-37-0**, Gallium indium phosphide (Ga0.51In0.49P)
(high-efficiency gallium indium phosphide/gallium indium arsenide tandem **solar cells** lattice-matched to **germanium substrates**)
RN 106770-37-0 HCA
CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium gallium phosphide tandem **solar cell**; gallium indium arsenide tandem **solar cell**; **germanium substrate** tandem **solar cell**
IT Tandem **solar cells**
(high-efficiency gallium indium phosphide/gallium indium arsenide tandem **solar cells** lattice-matched to

germanium substrates)

IT 7440-56-4, Germanium, uses 106495-91-4, Gallium indium arsenide (Ga0.99In0.01As) **106770-37-0**, Gallium indium phosphide (Ga0.51In0.49P)
(high-efficiency gallium indium phosphide/gallium indium arsenide tandem **solar cells** lattice-matched to **germanium substrates**)

L24 ANSWER 18 OF 19 HCA COPYRIGHT 2005 ACS on STN
130:354702 Lattice tilt and relaxation in **InGaP**/GaAs/Ge **solar cells** on miscut substrates. Hess, R. R.; Moore, C. D.; Goorsky, M. S. (UCLA, Department of Materials Science and Engineering, Los Angeles, CA, 90095, USA). Journal of Physics D: Applied Physics, 32(10A), A16-A20 (English) 1999. CODEN: JPAPBE. ISSN: 0022-3727. Publisher: Institute of Physics Publishing.

AB Strain relaxation and epitaxial layer tilt has been investigated for group III-V based tandem **solar cells** grown on miscut **Ge substrates.** AlGaAs/**InGaP** /GaAs layers were grown by metalorg. vapor phase epitaxy on substrates miscut by 9.degree. along a low crystallog. symmetry direction. We observe the GaAs buffer layer grown on the substrate to be 86% relaxed. The GaAs layer is tilted by 60 arcsec from the substrate, as detd. by triple axis x-ray diffraction. This tilt stems from the miscut, the polar/non-polar interface, and from the miscut direction lying away from a high symmetry direction. The obsd. magnitude of the tilt is not predicted well by existing models. Subsequently grown Al0.8Ga0.2As and In0.5Ga0.5P device layers are pseudomorphic with respect to the GaAs buffer layer, and exhibit the expected layer tilting of 58 and 125 arcsec, resp., with respect to the **Ge substrate.** There is no rotation of the epitaxial layers with respect to the GaAs buffer layer.

IT **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(lattice tilt and relaxation in aluminum gallium arsenide/gallium indium phosphide/gallium arsenide **solar cells** on **germanium** miscut **substrates**)

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium phosphide **solar cell** **germanium** miscut **substrate**; gallium arsenide

solar cell miscut substrate; aluminum gallium arsenide **solar cell** miscut substrate

IT Tandem **solar cells**
(lattice tilt and relaxation in aluminum gallium arsenide/gallium indium phosphide/gallium arsenide **solar cells** on **germanium** miscut **substrates**)

IT 1303-00-0, Gallium arsenide, uses 7440-56-4, Germanium, uses
12776-63-5, Gallium indium phosphide (Ga0.5In0.5P)
106312-10-1, Aluminum gallium arsenide (Al0.8Ga0.2As)
(lattice tilt and relaxation in aluminum gallium arsenide/gallium indium phosphide/gallium arsenide **solar cells** on **germanium** miscut **substrates**)

L24 ANSWER 19 OF 19 HCA COPYRIGHT 2005 ACS on STN

127:164350 Production experience with large area, dual junction space cells. Yeh, Y. C. M.; Chu, C. L.; Krogen, J.; Ho, F. F.; Datum, G. C.; Billets, S.; Olson, J. M.; Timmons, M. L. (TECSTAR INC., Applied Solar Division, City of Industry, CA, 91745-1002, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 25th, 187-190 (English) 1996. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB Dual junction (DJ) space cells, comprising **GaInP**/GaAs cells grown on **Ge substrates**, are now in prodn. A conservative DJ cell design (efficiency around 22% AMO) was specified. The paper surveys the development phase, and the prodn. scale-up. Details of current DJ cell performance are included.

IT **106312-00-9**, Gallium indium phosphide
(prodn. experience with large area, dual junction space cells)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST gallium indium phosphide **solar cell** spacecraft

IT **Solar cells**
Space vehicles
(prodn. experience with large area, dual junction space cells)

IT 1303-00-0, Gallium arsenide, uses 7440-56-4, Germanium, uses
106312-00-9, Gallium indium phosphide
(prodn. experience with large area, dual junction space cells)

=> d l25 1-34 cbib abs hitstr hitind

L25 ANSWER 1 OF 34 HCA COPYRIGHT 2005 ACS on STN
140:360374 Method and apparatus of multiple-junction **solar cell** structure with high band gap heterojunction middle cell. Fatemi, Navid; Aiken, Daniel J.; Stan, Mark A. (USA). U.S. Pat. Appl. Publ. US 2004084694 A1 20040506, 12 pp. (English). CODEN: USXXCO. APPLICATION: US 2002-285780 20021031.

AB A method and a multijunction solar device having a high band gap heterojunction middle **solar cell** are disclosed. In one embodiment, a triple-junction solar device includes bottom, middle, and top cells. The bottom cell has a **germanium (Ge) substrate** and a buffer layer, wherein the buffer layer is disposed over the **Ge substrate.** The middle cell contains a heterojunction structure, which further includes an emitter layer and a base layer that are disposed over the bottom cell. The top cell contains an emitter layer and a base layer disposed over the middle cell.

IT **7440-56-4**, Germanium, uses **106312-00-9**, Indium gallium phosphide
(method and app. of multiple-junction **solar cell** structure with high band gap heterojunction middle cell)

RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM H01L031-0336
INCL 257200000
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST multiple junction **solar cell** structure high band gap heterojunction
IT Heterojunction **solar cells**
Semiconductor junctions
Tunnel junctions
(method and app. of multiple-junction **solar cell** structure with high band gap heterojunction middle

cell)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses 37382-15-3, Aluminum gallium arsenide 106070-25-1, Indium gallium arsenide **106312-00-9**, Indium gallium phosphide
(method and app. of multiple-junction **solar cell** structure with high band gap heterojunction middle cell)

L25 ANSWER 2 OF 34 HCA COPYRIGHT 2005 ACS on STN

140:137167 Growth and characterization of high-Ge content Si-**Ge** virtual **substrates.** Erdtmann, M.; Carroll, M.; Carlin, J.; Langdo, T. A.; Westhoff, R.; Leitz, C.; Yang, V.; Currie, M. T.; Lochtefeld, A.; Petrocelli, K.; Vineis, C. J.; Badawi, H.; Bulsara, M. T.; Ringel, S.; Andre, C. L.; Khan, A.; Hudait, M. K. (AmberWave Systems Corp., Salem, NH, 03079, USA). Proceedings - Electrochemical Society, 2003-11(State-of-theArt Program on Compound Semiconductors XXXIX and Nitride and Wide Bandgap Semiconductors for Sensors, Photonics, and Electronics IV), 106-117 (English) 2003. CODEN: PESODO. ISSN: 0161-6374. Publisher: Electrochemical Society.

AB Si1-xGex virtual substrates with relaxed graded buffers grown in industrial LPCVD reactors on 150 mm and 200 mm diam. wafers are presented with compns. up to x = 1. By taking advantage of an intermediate planarization step, the authors are able to achieve dislocation glide limited relaxation throughout the growth of the entire graded buffer layer. This resulted in a threading dislocation d. of 2 .times. 105 cm-2 that was independent of the ultimate compn. for substrates with x > 0.4. Ge-on-Si virtual substrates exhibited an root-mean-square surface roughness of 3.27 nm for a 20 .mu.m .times. 20 .mu.m area and a very low d. of epitaxial defects. These substrates were used to fabricate both III-V **solar cells** and visible LEDs. The preliminary results of the devices showed no degrdn. in device performance from the graded buffer layer, demonstrating the com. readiness of the Si-**Ge** virtual **substrates.**

IT **106312-00-9**, Gallium indium phosphide (Ga0-1In0-1P)
(growth and characterization of high-germanium content **germanium**-silicon virtual **substrates**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 76-3 (Electric Phenomena)

Section cross-reference(s): 48, 52, 73
ST germanium silicon buffer VPE **solar cell** LED
fabrication
IT Polishing
(chem.-mech.; growth and characterization of high-germanium
content **germanium**-silicon virtual **substrates**)
IT Diffusion barrier
Electric current-potential relationship
Electroluminescent devices
Semiconductor device fabrication
Solar cells
Stress relaxation
Surface roughness
Threading dislocations
Vapor phase epitaxy
(growth and characterization of high-germanium content
germanium-silicon virtual **substrates**)
IT 7782-65-2, Germane 7803-51-2, Phosphorus trihydride 7803-62-5,
Silane, processes 19287-45-7, Diborane
(growth and characterization of high-germanium content
germanium-silicon virtual **substrates**)
IT 1303-00-0, Gallium arsenide, processes **106312-00-9**,
Gallium indium phosphide (Ga0-1In0-1P) 107102-89-6, Aluminum
gallium indium phosphide (Al0-1Ga0-1In0-1P)
(growth and characterization of high-germanium content
germanium-silicon virtual **substrates**)
IT 12623-02-8P, Germanium 50, silicon 50 (atomic) 12623-04-0P,
Germanium 30, silicon 70 (atomic) 12675-06-8P, Germanium 60,
silicon 40 (atomic) 37380-03-3P, Germanium 20, silicon 80 (atomic)
51845-19-3P, Germanium 90, silicon 10 (atomic) 72048-89-6P,
Germanium 80, silicon 20 (atomic) 76998-02-2P, Germanium 40,
silicon 60 (atomic) 112542-45-7P, Germanium 0-40, silicon 60-100
(atomic)
(growth and characterization of high-germanium content
germanium-silicon virtual **substrates**)
IT 7440-21-3, Silicon, processes
(growth and characterization of high-germanium content
germanium-silicon virtual **substrates**)

L25 ANSWER 3 OF 34 HCA COPYRIGHT 2005 ACS on STN
139:182758 Impact of threading dislocations on both n/p and p/n single
junction GaAs cells grown on **Ge**/SiGe/Si **substrates**
. Andre, C. L.; Khan, A.; Gonzalez, M.; Hudait, M. K.; Fitzgerald,
E. A.; Carlin, J. A.; Currie, M. T.; Leitz, C. W.; Langdo, T. A.;
Clark, E. B.; Wilt, D. M.; Ringel, S. A. (Department of Electrical
Engineering, The Ohio State University, Columbus, OH, 43210, USA).
Conference Record of the IEEE Photovoltaic Specialists Conference,
29th, 1043-1046 (English) 2002. CODEN: CRCNDP. ISSN: 0160-8371.
Publisher: Institute of Electrical and Electronics Engineers.

AB Single junction GaAs **solar cells** having an n/p polarity were grown on p-type **Ge**/SiGe/Si **substrates** for the first time. The cell performance and material properties of these n/p cells were compared with p/n cells grown on n-type **Ge**/SiGe/Si **substrates** for which record high minority carrier hole lifetimes of 10 ns and open circuit voltages (Voc) greater than 980 mV (AM0) were achieved. The initial n/p exptl. results and correlations with theor. predictions have indicated that for comparable threading dislocation densities (TDD), n/p cells have longer minority carrier diffusion lengths, but reduced minority carrier lifetimes for electrons in the p-type GaAs base layers. This suggests that a lower TDD tolerance exists for n/p cells compared to p/n cells, which has implications for the optimization of n/p high efficiency cell designs using alternative substrates.

IT **7440-56-4**, Germanium, uses
(dopants; impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IT **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST gallium arsenide **solar cell** fabrication threading dislocation

IT Vapor deposition process
(chem.; impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

IT Molecular beam epitaxy
Solar cells

Threading dislocations
(impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

IT Vapor deposition process
(metalorg.; impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

IT Electric current carriers
(minority; impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

IT **7440-56-4**, Germanium, uses
(dopants; impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

IT 1303-00-0, Gallium arsenide, uses 7440-21-3, Silicon, uses 11148-21-3 **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P) 106070-09-1, Aluminum gallium arsenide (Al0.3Ga0.7As) 106312-09-8, Aluminum gallium arsenide (Al0.2Ga0.8As)
(impact of threading dislocations on both n/p and p/n single junction GaAs cells grown on **Ge**/SiGe/Si **substrates**)

L25 ANSWER 4 OF 34 HCA COPYRIGHT 2005 ACS on STN

139:166849 Wafer bonding and layer transfer processes for 4-junction high efficiency **solar cells.** Zahler, James M.; Fontcuberta i Morral, Anna; Ahn, Chang-Geun; Atwater, Harry A.; Wanlass, Mark W.; Chu, Charles; Iles, Peter A. (Thomas J. Watson Laboratory of Applied Physics, California Institute of Technology, Pasadena, CA, 91125, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 29th, 1039-1042 (English) 2002. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB A four-junction cell design consisting of InGaAs, InGaAsP, GaAs, and Ga0.5In0.5P subcells could reach 1.times.AM0 efficiencies of 35.4%, but relies on the integration of non-lattice-matched materials. Wafer bonding and layer transfer processes show promise in the fabrication of InP/Si epitaxial templates for growth of the bottom InGaAs and InGaAsP subcells on a Si support substrate. Subsequent wafer bonding and layer transfer of a thin Ge layer onto the lower subcell stack can serve as an epitaxial template for GaAs and Ga0.5In0.5P subcells. Present results indicate that optically active III/V compd. semiconductors can be grown on both Ge/Si and InP/Si heterostructures. Current-voltage elec. characterization of the interfaces of these structures indicates that both InP/Si and Ge/Si interfaces have specific resistances lower than 0.1 .OMEGA.cm2 for heavily doped wafer bonded interfaces, enabling back surface

power extn. from the finished cell structure.
IT **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(wafer bonding and layer transfer processes for 4-junction high efficiency **solar cells**)
RN 12776-63-5 HCA
CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**wafer** bonding and layer transfer processes for 4-junction high efficiency **solar cells**)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar cell** heterostructure wafer bonding layer transfer
IT Epitaxy
Interface
Interfacial structure
Ion implantation
Solar cells
(wafer bonding and layer transfer processes for 4-junction high efficiency **solar cells**)
IT 12586-59-3, Proton 14234-48-1, processes
(implantation; wafer bonding and layer transfer processes for 4-junction high efficiency **solar cells**)
IT 1303-00-0, Gallium arsenide, uses 12645-36-2, Gallium indium arsenide phosphide ((Ga,In)(As,P)) **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P) 106070-25-1, Gallium indium arsenide (GaInAs)
(wafer bonding and layer transfer processes for 4-junction high efficiency **solar cells**)
IT 7440-21-3, Silicon, uses **7440-56-4**, **Germanium**, uses 22398-80-7, Indium phosphide, uses
(**wafer** bonding and layer transfer processes for 4-junction high efficiency **solar cells**)

L25 ANSWER 5 OF 34 HCA

139:119991 Apparatus and method for integral bypass diode in **solar cells.** Sharps, Paul R.; Aiken, Daniel J.; Collins, Doug; Stan, Mark A. (Emcore Corporation, USA). U.S. Pat. Appl. Publ. US 2003140962 A1 20030731, 23 pp., Cont.-in-part of U.S. Ser. No. 999,598. (English). CODEN: USXXCO. APPLICATION: US 2002-280593 20021024. PRIORITY: US 2001-999598 20011024.

AB A **solar cell** having a multijunction **solar cell** structure with a bypass diode is disclosed. The bypass diode provides a reverse bias protection for the multijunction **solar cell** structure. In one embodiment, the multifunction **solar cell** structure includes a substrate, a bottom cell, a middle cell, a top cell, a bypass diode, a lateral conduction layer, and a shunt. The lateral conduction layer is deposited over the top cell. The bypass diode is deposited over the lateral conduction layer. One side of the shunt is connected to the substrate and another side of the shunt is connected to the lateral conduction layer. In another embodiment, the bypass diode contains an i-layer to enhance the diode performance.

IT **12776-63-5**, Gallium indium phosphide gainp2
(app. and method for integral bypass diode in **solar cells**)

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate**; app. and method for integral bypass diode in **solar cells**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L031-00

INCL 136249000; 136255000; 438074000

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST **solar cell** integral bypass diode

IT **Solar cells**
Tandem **solar cells**
(app. and method for integral bypass diode in **solar**

cells)

IT Diodes
(integral bypass; app. and method for integral bypass diode in **solar cells**)

IT 1303-00-0, Gallium arsenide (GaAs), uses 12774-46-8, Aluminum indium phosphide (Al0.5In0.5P) **12776-63-5**, Gallium indium phosphide gainp2 107102-89-6, Aluminum gallium indium phosphide Algainp
(app. and method for integral bypass diode in **solar cells**)

IT **7440-56-4**, **Germanium**, uses
(**substrate**; app. and method for integral bypass diode in **solar cells**)

L25 ANSWER 6 OF 34 HCA COPYRIGHT 2005 ACS on STN

139:29078 Enabling technologies for making GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates.
Mauk, M. G.; Balliet, J.; Feyock, B. W. (AstroPower, Inc., Newark, DE, 19716-2000, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 29th, 1062-1065 (English) 2002. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB Large-grain size (>1 mm), highly-oriented, thin (0.5 to 5 .mu.m) films of Ge were created on fused SiO2, sintered Al2O3 ceramic, and low-cost polysilicon sheet substrates. A H2O-vapor mediated, close-spaced vapor transport process was used to deposit Ge, followed by a recrystn. step. An alternative chem. vapor transport process using I vapor was also developed for low-cost deposition and epitaxy of Ge and GaAs. Ge films with a highly oriented texture and with the lateral dimension of grains >1 mm were obtained on the three substrates. These structures are intended for use as **Ge** (coated) surrogate **substrates** for epitaxial growth of high-performance GaAs/**InGaP solar cells.**

IT **7440-56-4**, Germanium, processes
(enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates coated with)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 76-3 (Electric Phenomena)
Section cross-reference(s): 52

ST alumina silica polysilicon **substrate germanium** coating **solar cell**

IT **Solar cells**

(enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates)

IT **7440-56-4**, Germanium, processes
(enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates coated with)

IT 7631-86-9, Silica, uses
(fused, substrate; enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates)

IT 1344-28-1, Alumina, uses
(sintered, substrate; enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates)

IT 7440-21-3, Polysilicon, uses
(substrate; enabling technol. for fabrication of GaAs-based thin-film **solar cells** on ceramic and polysilicon substrates)

L25 ANSWER 7 OF 34 HCA

138:140083 Method and apparatus of **solar cell** having a bypass diode for reverse bias protection. Chu, Chaw-Long (Emcore Corporation, USA). PCT Int. Appl. WO 2003012880 A2 20030213, 38 pp. DESIGNATED STATES: W: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW; RW: AT, BE, BF, BJ, CF, CG, CH, CI, CM, CY, DE, DK, ES, FI, FR, GA, GB, GR, IE, IT, LU, MC, ML, MR, NE, NL, PT, SE, SN, TD, TG, TR. (English). CODEN: PIXXD2. APPLICATION: WO 2002-US23978 20020726. PRIORITY: US 2001-PV305503 20010727.

AB Reverse bias protection for a **solar cell** is provided with a diode on the **solar cell.** In one embodiment, the Schottky diode is formed at the interface between a metallic diode contact and a semiconductor substrate on which the **solar cell** is grown. The **solar cell** includes a **Ge substrate**, which may further include a photoactive junction. In one embodiment, the Schottky diode is provided in a trough or recess extending through the **solar cell** layers to the front surface of the substrate. In this embodiment, the Schottky diode is elec. connected across some or all of the **cells** of the **solar cell** structure with a jumper bar or other suitable interconnect. In another embodiment, the Schottky diode is provided on a back surface of the substrate, with a C-clamp interconnecting at least one **solar cell** contact

to the diode contact.
IT **106312-00-9**, Gallium indium phosphide
(method and app. of **solar cell** having bypass
diode for reverse bias protection)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate**; method and app. of **solar cell** having bypass diode for reverse bias protection)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L031-068
ICS H01L031-18; H01L027-142
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar cell** bypass diode reverse bias protection
IT Diodes
(bypass; method and app. of **solar cell** having
bypass diode for reverse bias protection)
IT Electric contacts
Schottky diodes
Solar cells
Tandem **solar cells**
(method and app. of **solar cell** having bypass
diode for reverse bias protection)
IT 7440-38-2, Arsenic, uses
(dopant; method and app. of **solar cell** having
bypass diode for reverse bias protection)
IT 7440-05-3, Palladium, uses 7440-22-4, Silver, uses 7440-32-6, Titanium, uses
(elec. contact; method and app. of **solar cell**
having bypass diode for reverse bias protection)
IT 1303-00-0, Gallium arsenide (GaAs), uses 37382-15-3, Aluminum gallium arsenide **106312-00-9**, Gallium indium phosphide
107121-39-1, Aluminum indium phosphide
(method and app. of **solar cell** having bypass
diode for reverse bias protection)

IT **7440-56-4**, **Germanium**, uses
(**substrate**; method and app. of **solar cell** having bypass diode for reverse bias protection)

L25 ANSWER 8 OF 34 HCA COPYRIGHT 2005 ACS on STN
138:109550 Development of low-cost substrates and deposition processes for high-performance GaAs-based thin-film **solar cells.** Mauk, M.; Balliet, J.; Feyock, B. (AstroPower, Inc., Newark, DE, 19711, USA). Proceedings - NCPV Program Review Meeting, Lakewood, CO, United States, Oct. 14-17, 2001, 271-272. National Technical Information Service: Springfield, Va. (English) 2001. CODEN: 69DAU4.
AB We present results for the first phase of an effort to develop large-grain (>1-mm), highly-oriented, 5-.mu. thick Ge films on fused silica and alumina ceramics. We use a water-vapor mediated, close-spaced vapor transport (CSVT) process to deposit Ge, followed by a recrystn. step. These structures are intended for use as **Ge** (coated) surrogate **substrates** for epitaxial growth of high-performance GaAs/**InGaP solar cells.**
IT **7440-56-4P**, Germanium, uses
(metalorg. deposition of; development of low-cost **Ge** -coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-3 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST germanium film metalorg vapor deposition **solar cell** substrate; alumina **substrate solar cell germanium** chem vapor deposition; silica **substrate solar cell germanium** chem vapor deposition
IT **Solar cells**
(development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
IT Vapor deposition process
(metalorg.; development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
IT Recrystallization
(of germanium film; development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance

GaAs-based thin-film **solar cells**)
IT Grain size
(of germanium films; development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
IT Ceramics
(**solar-cell** substrates; development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
IT 1344-28-1, Alumina, uses 60676-86-0, Fused silica
(ceramic substrates; development of low-cost **Ge**-coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)
IT **7440-56-4P**, Germanium, uses
(metalorg. deposition of; development of low-cost **Ge** -coated **substrates** and deposition processes for high-performance GaAs-based thin-film **solar cells**)

L25 ANSWER 9 OF 34 HCA COPYRIGHT 2005 ACS on STN
138:92636 III-V compound multi-junction **solar cells**: present and future. Yamaguchi, Masafumi (Toyota Technological Institute, Tempaku, Nagoya, 468-8511, Japan). Solar Energy Materials and Solar Cells, 75(1-2), 261-269 (English) 2003. CODEN: SEMCEQ. ISSN: 0927-0248. Publisher: Elsevier Science B.V..
AB A review of present status of research and development of super-high-efficiency multi-junction **solar cells** in Japan. The **InGaP**/InGaAs/Ge monolithic cascade three-junction **solar cells** with newly recorded efficiency of 31.7% at air mass 1.5 (1-sun) were achieved on **Ge substrates**, in addn. to **InGaP** /GaAs//InGaAs mech. stacked three-junction cells with efficiency of 33.3%. Future prospects for realizing super-high-efficiency and low-cost multi-junction **solar cells** are also discussed.
CC 52-0 (Electrochemical, Radiational, and Thermal Energy Technology)
ST review group III V compd **solar cell**
IT **Solar cells**
(status of research and development of group III-V compd. multi-junction **solar cells**)
IT Group IIIA element pnictides
(status of research and development of group III-V compd. multi-junction **solar cells**)

L25 ANSWER 10 OF 34 HCA COPYRIGHT 2005 ACS on STN
137:8542 Germanium layer transfer to silicon for photovoltaic applications. Zahler, James M.; Ahn, Chang-Geun; Zaghi, Shahrooz; Atwater, Harry A.; Chu, Charles; Iles, Peter (Thomas J. Watson

Laboratory of Applied Physics, California Institute of Technology, Pasadena, CA, 91125, USA). Thin Solid Films, 403-404, 558-562 (English) 2002. CODEN: THSFAP. ISSN: 0040-6090. Publisher: Elsevier Science S.A..

AB We have successfully used hydrophobic direct-wafer bonding, along with H-induced layer splitting of Ge, to transfer 700-nm-thick, single-crystal Ge (100) films to Si (100) substrates without using a metallic bonding layer. The metal-free nature of the bond makes the bonded wafers suitable for subsequent epitaxial growth of triple-junction **GaInP**/GaAs/Ge **solar cell** structures at high temps., without concern about metal contamination of the active region of the device. Contact-mode at. force microscopy images of the transferred **Ge surface** generated by hydrogen-induced layer-splitting reveals root mean square (rms) surface roughness of between 10 and 23 nm. Elec. measurements indicate ohmic I-V characteristics for as-bonded Ge layers bonded to silicon substrates with .apprx.400 .OMEGA. cm-2 resistance at the interface. Triple-junction **solar cell** structures grown on these Ge/Si heterostructure templates by metal-org. chem. vapor deposition show comparable photoluminescence intensity and minority carrier lifetime to a control structure grown on bulk Ge. An epitaxial Ge buffer layer is grown to smooth the cleaved **surface** of the **Ge** heterostructure and reduces the rms surface roughness from .apprx.11 to as low as 1.5 nm, with a mesa-like morphol. that has a top surface roughness of under 1.0 nm, providing a promising surface for improved GaAs growth.

IT **7440-56-4**, Germanium, processes
(germanium layer transfer to silicon for photovoltaic applications)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST **solar cell** germanium layer transfer silicon

IT **Solar cells**
(germanium layer transfer to silicon for photovoltaic applications)

IT 7440-21-3, Silicon, processes **7440-56-4**, Germanium, processes
(germanium layer transfer to silicon for photovoltaic applications)

L25 ANSWER 11 OF 34 HCA COPYRIGHT 2005 ACS on STN

135:306110 Gas-source molecular beam epitaxy of GaAs on Ge for **solar cell** applications. Laaksonen, S.; Keranen,

J.; Li, W.; Haapamaa, J.; Leinonen, P.; Pessa, M.; Lepisto, T. (Optoelectronics Research Centre, Tampere University of Technology, Tampere, FIN-33101, Finland). European Photovoltaic Solar Energy Conference, Proceedings of the International Conference, 16th, Glasgow, United Kingdom, May 1-5, 2000, Volume 1, 955-958. Editor(s): Scheer, Hermann. James & James (Science Publishers) Ltd.: London, UK. (English) 2000. CODEN: 69BOEK.

AB GaAs layers have been grown by gas source mol. beam epitaxy on **Ge**(001) **substrates** offcut towards [111] in purpose of achieving device quality material for space **solar cell** applications and prodn. Grown epilayers have been investigated using transmission electron microscopy, at. force microscopy, and x-ray diffraction. Elec. characterization has been performed by growing **GaInP**/GaAs tunneling junction diodes on **Ge substrate.** Earlier work show that to bury the impurities on the **Ge substrate**, a thin **Ge** buffer layer should be used in the prodn. of clean starting surface for growth of antiphase domain free material. In this context, however, we report the result of very highly reproducible device quality GaAs films grown on epi-ready **Ge substrates** without any buffer layer at the interface as a purpose of simplifying the growth procedure and the growth system.

IT **7440-56-4**, Germanium, processes
(gas-source mol. beam epitaxy of GaAs on Ge for **solar cell** applications)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST space **solar cell** gallium arsenide germanium epitaxy

IT Epitaxy
Solar cells
Space vehicles
(gas-source mol. beam epitaxy of GaAs on Ge for **solar cell** applications)

IT 1303-00-0, Gallium arsenide, processes **7440-56-4**, Germanium, processes
(gas-source mol. beam epitaxy of GaAs on Ge for **solar cell** applications)

L25 ANSWER 12 OF 34 HCA COPYRIGHT 2005 ACS on STN

135:155146 High-efficiency GaInP2/GaAs/Ge dual and triple junction **solar cells** for space applications. Karam, Nasser H.; Ermer, James H.; King, Richard R.; Haddad, Moran; Cai, Li; Joslin, David E.; Krut, Dimitri D.; Takahashi, Mark; Eldredge, Jack

W.; Nishikawa, Warren; Cavicchi, Bruce T.; Lillington, David R. (Spectrolab, Inc., Sylmar, CA, 91342, USA). European Commission, [Report] EUR, EUR 18656, 2nd World Conference on Photovoltaic Solar Energy Conversion, 1998, Volume III, 3534-3539 (English) 1998. CODEN: CECED9. ISSN: 1018-5593.

AB This paper addresses the recent progress in the development and current status of high-efficiency GaInP2/GaAs/Ge dual junction and triple junction cells at Spectrolab. Large-area deposition of GaInP2/GaAs/Ge dual junction and triple junction **solar cell** structures on 100 mm diam. **Ge substrates** by metalorg. vapor phase epitaxy has been developed. We report on the end-of-life efficiency and temp. coeffs. for dual and triple junction cells. The fraction of remaining power (P/P0) of 0.83 was measured for double junction and triple junction after irradn. with 1 .times. 1015 1 MeV electrons/cm2. We also report on a record efficiency GaInP2/GaAs/Ge triple junction cell of 25.8% (4 cm2 area) and 25.4% (21.65 cm2 area) air-mass 0, at 28.degree..

IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(development and current status of high-efficiency GaInP2/GaAs/Ge dual junction and triple junction **solar cells** for space applications)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium phosphide multijunction **solar cell** development; gallium arsenide multijunction **solar cell** development; germanium multijunction **solar cell** development

IT **Solar cells**
(development and current status of high-efficiency GaInP2/GaAs/Ge dual junction and triple junction **solar cells** for space applications)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium,

uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(development and current status of high-efficiency GaInP2/GaAs/Ge dual junction and triple junction **solar cells** for space applications)

L25 ANSWER 13 OF 34 HCA COPYRIGHT 2005 ACS on STN
135:124899 GaInP2 and GaAs **solar cells** grown on Si substrate. Chu, C. (Tecstar/ASD, City of Industry, CA, 91745-1002, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 28th, 1250-1252 (English) 2000. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB Large size Si substrates coated with a thin layer of single crystal Ge were used to grow GaAs and GaInP2 **solar cells** using MOCVD. Preliminary evaluation indicated (1) both GaAs and GaInP2 were highly cryst. epi-layers, (2) quantum efficiency of GaInP2 cell on Si substrate can reach 94% of high quality GaInP2 on **Ge substrate** and that of GaAs cell on Si substrate can reach 83.4%, and (3) a 5000 thermal cycle test of temp. range from +170.degree.C to -100.degree.C did not damage the **solar cell.** These results showed that a properly prepd. Ge layer on Si can relax strain and grow a high quality GaInP2 and GaAs **solar cell**, with a practical efficiency for space application.

IT **12776-63-5**, gallium indium phosphide gainp2
(gallium indium phosphide and gallium arsenide **solar cells** grown on Si substrate)

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST **solar cell** gallium indium phosphide silicon substrate; gallium arsenide **solar cell** silicon substrate

IT Luminescence
Solar cells
(gallium indium phosphide and gallium arsenide **solar cells** grown on Si substrate)

IT Vapor deposition process
(metalorg.; gallium indium phosphide and gallium arsenide **solar cells** grown on Si substrate)

IT 1303-00-0, Gallium arsenide (GaAs), uses 7440-21-3, Silicon, uses
12776-63-5, gallium indium phosphide gainp2
(gallium indium phosphide and gallium arsenide **solar cells** grown on Si substrate)

L25 ANSWER 14 OF 34 HCA COPYRIGHT 2005 ACS on STN
135:124876 Radiation response of dual-junction GayIn1-yP/Ga1-xInxAs **solar cells.** Dimroth, F.; Bett, A. W.; Walters, R. J.; Summers, G. P.; Messenger, S. R.; Takamoto, T.; Ikeda, E.; Imaizumi, M.; Anzawa, O.; Matsuda, S. (Fraunhofer Institute for Solar Energy Systems, Freiburg, D-79100, Germany). Conference Record of the IEEE Photovoltaic Specialists Conference, 28th, 1110-1113 (English) 2000. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB The radiation response of dual-junction GayIn1-yP/Ga1-xInxAs **solar cells** grown with 0.35 <y< 0.51 and 0.01 < x < 0.17 is presented. These lattice-mismatched structures were grown by metal-org.-vapor-phase-epitaxy on GaAs or **Ge substrates.** Measurement of the photovoltaic output of the cells made under simulated one-sun, AM0 spectral conditions shows that the new dual-junction GaxIn1-xP/GayIn1-yAs cells perform as well or better than com. available multijunction cells. Measurement of the quantum efficiency gives insight into which subcell dets. the total cell degrdn. under proton irradn. As has been found previously for the GayIn1-yP/GaAs tandem cell, degrdn. of the new GayIn1-yP/Ga1-xInxAs material combination is controlled by the bottom **solar cell.** Anal. of the irradn. data is used to det. the basic mechanisms governing the radiation response of these devices, including the effect of stoichiometry, lattice-mismatch and cell structure.

IT **106312-00-9**, Gallium indium phosphide **106770-37-0**, Gallium indium phosphide Ga0.51In0.49P **128089-51-0**, Gallium indium phosphide Ga0.35In0.65P
(radiation response of dual-junction gallium indium arsenide/gallium indium phosphide **solar cells**
)

RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

RN 106770-37-0 HCA
CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

RN 128089-51-0 HCA
CN Gallium indium phosphide (Ga0.35In0.65P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.65	7440-74-6
Ga	0.35	7440-55-3

IT **7440-56-4**, germanium, uses
(radiation response of dual-junction gallium indium arsenide/gallium indium phosphide **solar cells**
)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar cell** gallium indium phosphide dual junction
IT Metalorganic vapor phase epitaxy
Solar cells
Tandem **solar cells**
(radiation response of dual-junction gallium indium arsenide/gallium indium phosphide **solar cells**
)
IT 106070-25-1, Gallium indium arsenide **106312-00-9**, Gallium indium phosphide 106312-09-8, Aluminum gallium arsenide al0.2ga0.8as **106770-37-0**, Gallium indium phosphide Ga0.51In0.49P 107404-65-9, Gallium indium arsenide Ga0.97In0.03As 110584-29-7, Gallium indium arsenide Ga0.83In0.17As **128089-51-0**, Gallium indium phosphide Ga0.35In0.65P
(radiation response of dual-junction gallium indium arsenide/gallium indium phosphide **solar cells**
)
IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, germanium, uses
(radiation response of dual-junction gallium indium

arsenide/gallium indium phosphide **solar cells**
)

L25 ANSWER 15 OF 34 HCA COPYRIGHT 2005 ACS on STN
135:124845 Triple-junction **solar cell** efficiencies above 32%: The promise and challenges of their application in high-concentration-ratio PV systems. Cotal, H. L.; Lillington, D. R.; Ermer, J. H.; King, R. R.; Karam, N. H.; Kurtz, S. R.; Friedman, D. J.; Olson, J. M.; Ward, J. S.; Duda, A.; Emery, K. A.; Moriarty, T. (Spectrolab, Inc., Sylmar, CA, 91342, USA). Conference Record of the IEEE Photovoltaic Specialists Conference, 28th, 955-960 (English) 2000. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB Results from Spectrolab-grown Ga0.5In0.5P/GaAs/Ge structures optimized for the AM1.5D spectrum are described along with progress toward developing next-generation multijunction **solar cells** for high concn. ratios (X). The epitaxially-grown layers were processed into triple junction cells both at Spectrolab and NREL, and I-V tested vs. X. Cells were tested with efficiencies as high as 32.4% near 372 suns. The FF limited the performance with increasing X as a result of the increased role of the series resistance. The Voc vs. X showed its log-linear dependence on Isc over 1000 suns. Based on recent cell improvements for space applications, multijunction cells appear to be ideal candidates for high efficiency, cost effective, PV concentrator systems. Future development of new 1-eV materials for space cells, and further redn. in **Ge wafer** costs, promises to achieve cells with efficiencies > 40% that cost $0.3/W or less at concn. levels between 300 to 500 suns.

IT **7440-56-4**, Germanium, uses **347861-18-1**, Gallium indium phosphide Ga0.5In0.5P
(triple-junction **solar cell** and challenges of their application in high-concn.-ratio PV systems)

RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 347861-18-1 HCA
CN Gallium indium phosphide (Ga0.05In0.05P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.05	7440-74-6
Ga	0.05	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST multijunction concentrator **solar cell** gallium
indium phosphide
IT **Solar cells**
(concentrator; triple-junction **solar cell** and
challenges of their application in high-concn.-ratio PV systems)
IT Electric current-potential relationship
Electric resistance
Tandem **solar cells**
(triple-junction **solar cell** and challenges of
their application in high-concn.-ratio PV systems)
IT 1303-00-0, Gallium arsenide (GaAs), uses **7440-56-4**,
Germanium, uses **347861-18-1**, Gallium indium phosphide
Ga0.5In0.5P
(triple-junction **solar cell** and challenges of
their application in high-concn.-ratio PV systems)

L25 ANSWER 16 OF 34 HCA
135:35211 Multijunction photovoltaic cell using a silicon or silicon-
germanium substrate. King, Richard R.; Karam,
Nasser H.; Haddad, Moran (The Boeing Company, USA). Eur. Pat. Appl.
EP 1109230 A2 20010620, 25 pp. DESIGNATED STATES: R: AT, BE, CH,
DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, MC, PT, IE, SI, LT, LV,
FI, RO. (English). CODEN: EPXXDW. APPLICATION: EP 2000-126168
20001130. PRIORITY: US 1999-454063 19991202.
AB A monolithic, multijunction photovoltaic cell is proposed,
comprising: an active substrate subcell comprising one of Si, SiGe
and pure **Ge**, the **substrate** subcell having a side
and being characterized by a substrate subcell bandgap and a
substrate subcell lattice const.; at least one subcell disposed
adjacent the side, the subcell being characterized by a subcell
lattice const. that is different than the substrate subcell lattice
const.; and a transition layer intermediate the side and the
subcell.
IT **7440-56-4**, Germanium, uses **107068-90-6**, Gallium
indium phosphide Ga0.52In0.48P **110666-82-5**, Gallium indium
phosphide Ga0.6In0.4P **118692-57-2**, Gallium indium
phosphide Ga0.55In0.45P
(multijunction photovoltaic cell using silicon or silicon-
germanium substrate)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 107068-90-6 HCA
CN Gallium indium phosphide (Ga0.52In0.48P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.48	7440-74-6
Ga	0.52	7440-55-3

RN 110666-82-5 HCA
CN Gallium indium phosphide (Ga0.6In0.4P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.4	7440-74-6
Ga	0.6	7440-55-3

RN 118692-57-2 HCA
CN Gallium indium phosphide (Ga0.55In0.45P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.45	7440-74-6
Ga	0.55	7440-55-3

IC ICM H01L031-068
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST **solar cell** silicon **germanium substrate**; photovoltaic cell silicon **germanium substrate**
IT Photoelectric devices
Solar cells
(multijunction photovoltaic cell using silicon or silicon-**germanium substrate**)
IT 1303-00-0, Gallium arsenide, uses 7440-21-3, Silicon, uses **7440-56-4**, Germanium, uses 11148-21-3 12064-03-8, Gallium antimonide 12645-36-2, Gallium indium arsenide phosphide 53218-65-8, Germanium 92, silicon 8 atomic 55000-69-6, Germanium 98, silicon 2 atomic **107068-90-6**, Gallium indium phosphide Ga0.52In0.48P 108821-75-6, Gallium arsenide phosphide GaAs0.83P0.17 108915-75-9, Antimony gallium arsenide Sb0.1GaAs0.9 **110666-82-5**, Gallium indium phosphide Ga0.6In0.4P 118340-56-0, Gallium indium arsenide Ga0.73In0.27As **118692-57-2**, Gallium indium phosphide Ga0.55In0.45P 120472-49-3, germanium 83, silicon 17 atomic 130042-18-1, Gallium arsenide phosphide GaAs0.93P0.07

(multijunction photovoltaic cell using silicon or silicon-
germanium substrate)

L25 ANSWER 17 OF 34 HCA COPYRIGHT 2005 ACS on STN
134:283284 **Solar cells** and tunnel diodes. Ikeda,
Eiji (Japan Energy Corp., Japan). Jpn. Kokai Tokkyo Koho JP
2001102608 A2 20010413, 10 pp. (Japanese). CODEN: JKXXAF.
APPLICATION: JP 1999-273324 19990927.

AB The **solar cells** have a **Ge** **substrate**, a bottom cell on the substrate, a 1st doped 1st cond. type AlyIn1-yP layer having lattice structure matching the substrate on the bottom cell, a 1st highly doped 1st cond. type InxGa1-xP layer having matching lattice on the 1st doped layer, a 2nd highly doped 2nd cond. type InxGa1-xP layer having matching lattice on the 1st highly doped layer forming a tunnel junction with the 1st highly doped layer, a 2nd doped 2nd cond. type AlyIn1-yP layer on the 2nd highly doped layer, and a top cell on the 2nd doped layer. Tunnel diodes for semiconductor devices on **Ge** **substrates** have a 1st doped 1st cond. type AlyIn1-yP layer (0.45 .ltoreq.y .ltoreq.0.55), a 1st highly doped 1st cond. type InxGa1-xP layer (0.45 .ltoreq.x .ltoreq.0.55) on the 1st doped layer, a 2nd highly doped 2nd cond. type InxGa1-xP layer on the 1st highly doped layer forming a tunnel junction with the 1st highly doped layer, a 2nd doped 2nd cond. type AlyIn1-yP layer on the 2nd highly doped layer.

IT **112050-18-7**, Gallium indium phosphide (Ga0.99In0.01P)
(bottom **cells** in **solar cells** contg.
germanium substrates and semiconductor layer
with matching lattice structure)

RN 112050-18-7 HCA

CN Gallium indium phosphide (Ga0.99In0.01P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.01	7440-74-6
Ga	0.99	7440-55-3

IT **7440-56-4**, Germanium, uses **106770-37-0**, Gallium
indium phosphide (Ga0.51In0.49P)
(**solar cells** and tunnel diodes contg.
germanium substrates and semiconductor layer
with matching lattice structure)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 106770-37-0 HCA
CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

IC ICM H01L031-04
ICS H01L029-88
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST pnictide **solar cell** substrate lattice matching structure; tunnel diode pnictide substrate lattice matching structure; **germanium substrate** pnictide **solar cell** lattice matching structure
IT Crystal structure
Solar cells
Tunnel diodes
(**solar cells** and tunnel diodes contg. **germanium substrates** and semiconductor layer with matching lattice structure)
IT 1303-00-0, Gallium arsenide, uses 106070-25-1, Gallium indium arsenide 106495-91-4, Gallium indium arsenide (Ga0.99In0.01As) **112050-18-7**, Gallium indium phosphide (Ga0.99In0.01P)
(bottom **cells** in **solar cells** contg. **germanium substrates** and semiconductor layer with matching lattice structure)
IT **7440-56-4**, Germanium, uses **106770-37-0**, Gallium indium phosphide (Ga0.51In0.49P) 107102-89-6, Aluminum gallium indium phosphide 107102-99-8, Aluminum indium phosphide (Al0.52In0.48P)
(**solar cells** and tunnel diodes contg. **germanium substrates** and semiconductor layer with matching lattice structure)

L25 ANSWER 18 OF 34 HCA COPYRIGHT 2005 ACS on STN
134:118306 Recent developments in high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**: steps to next-generation PV cells. Karam, N. H.; King, R. R.; Haddad, M.; Ermer, J. H.; Yoon, H.; Cotal, H. L.; Sudharsanan, R.; Eldredge, J. W.; Edmondson, K.; Joslin, D. E.; Krut, D. D.; Takahashi, M.; Nishikawa, W.; Gillanders, M.; Granata, J.; Hebert, P.; Cavicchi, B. T.; Lillington, D. R. (Spectrolab, Inc., Sylmar, CA, 91342, USA). Solar Energy Materials and Solar Cells, 66(1-4), 453-466 (English) 2001. CODEN: SEMCEQ. ISSN: 0927-0248. Publisher: Elsevier Science

B.V..

AB Dual-junction Ga0.5In0.5P/GaAs **solar cells** on **Ge substrates** have rapidly gone from small, high-efficiency lab. cells, to large-area, high-efficiency cells manufd. at Spectrolab in high vol. Over 500,000 of these dual-junction cells with 27-cm2 area have been produced, with av. air-mass 0 (AM0) load point efficiency of 21.4%. The next step in the evolution of this type of multijunction **solar cell** has been taken, with the development of triple-junction Ga0.5In0.5P/GaAs/Ge cells. The addn. of the germanium third junction, plus several significant improvements in the device structure, have led to a measured efficiency of 27.0% (AM0, 28.degree.) at Spectrolab on large-area (>30 cm2) triple-junction cells. The triple-junction cell is now in prodn. at Spectrolab. Ga0.5In0.5P/GaAs/Ge cells are viable not only for non-concg. space applications, but also for terrestrial and space concentrator systems. Efficiencies up to 32.3% at 47 suns under the terrestrial AM1.5D spectrum have been achieved.

IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(fabrication of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium phosphide multijunction **solar cell** development; gallium arsenide multijunction **solar cell** development; germanium multijunction **solar cell** development

IT **Solar cells**
(fabrication of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(fabrication of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and

triple-junction **solar cells**)

L25 ANSWER 19 OF 34 HCA COPYRIGHT 2005 ACS on STN
134:103335 Monolithic bypass-diode and **solar-cell** string assembly. Boutros, Karim S.; Krut, Dmitri D.; Karam, Nasser H. (Hughes Electronics Corporation, USA). PCT Int. Appl. WO 2001006565 A1 20010125, 30 pp. DESIGNATED STATES: W: JP; RW: AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE. (English). CODEN: PIXXD2. APPLICATION: WO 2000-US7403 20000320. PRIORITY: US 1999-353526 19990714.

AB A method for making a **solar cell** with an integrated bypass diode comprises the steps of depositing a second layer having a first type of dopant on a first layer having an opposite type of dopant to the first type of dopant to form a **solar cell**, depositing a third layer having the first type of dopant on the second layer, depositing a fourth layer having the opposite type of dopant on the third layer, the third layer and fourth layer forming a bypass diode, selectively etching the third layer and the fourth layer to expose the second layer and the third layer, and applying contacts to the fourth layer, third layer, and the first layer to allow elec. connections to the assembly. The app. comprises a first layer having a first type of dopant, a second layer having a second type of dopant opposite to the first type of dopant, wherein the first layer and the second layer form a **solar cell**, a third layer, coupled to the second layer, and a fourth layer, coupled to the third layer, the third layer and the fourth layer forming a bypass diode.

IT **106312-00-9**, Gallium indium phosphide
(app. and method for fabrication of monolithic bypass-diode and **solar-cell** string assembly)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate**; app. and method for fabrication of monolithic bypass-diode and **solar-cell** string assembly)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L027-142
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar cell** integrated bypass diode
IT Diodes
Solar cells
(app. and method for fabrication of monolithic bypass-diode and **solar-cell** string assembly)
IT 1303-00-0, Gallium arsenide, uses 12063-98-8, Gallium phosphide, uses **106312-00-9**, Gallium indium phosphide
(app. and method for fabrication of monolithic bypass-diode and **solar-cell** string assembly)
IT 7440-21-3, Silicon, uses **7440-56-4**, **Germanium**, uses 22398-80-7, Indium phosphide, uses
(**substrate**; app. and method for fabrication of monolithic bypass-diode and **solar-cell** string assembly)

L25 ANSWER 20 OF 34 HCA COPYRIGHT 2005 ACS on STN
133:275222 Forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells.** Ermer, James H.; Cai, Li; Haddad, Moran; Cavicchi, Bruce T.; Karam, Nasser H. (Hughes Electronics Corporation, USA). PCT Int. Appl. WO 2000059045 A2 20001005, 18 pp. DESIGNATED STATES: W: JP; RW: AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE. (English). CODEN: PIXXD2. APPLICATION: WO 2000-US7402 20000320. PRIORITY: US 1999-280771 19990329.
AB A multilayer semiconductor structure includes a **germanium substrate** having a first surface. The **germanium substrate** has two regions, a bulk p-type germanium region, and a phosphorus-doped n-type germanium region adjacent to the first surface. A layer of a phosphide material overlies and contacts the first **surface** of the **germanium substrate**. A layer of gallium arsenide overlies and contacts the layer of the phosphide material, and elec. contacts may be added to form a **solar cell.** Addnl. photovoltaic junctions may be added to form multi-junction **solar cells.** The **solar cells** may be assembled together to form solar panels.
IT **106312-00-9P**, Gallium indium phosphide
(in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number

P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, Germanium, processes
(passivated; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L031-072
CC 76-3 (Electric Phenomena)
Section cross-reference(s): 52, 56
ST multilayer phosphide semiconductor structure phosphorus doped germanium; elec contact photovoltaic junction **solar cell** semiconductor device fabrication
IT Photoelectric devices
Solar cells
(forming multilayer semiconductor structure on P-doped **germanium substrate** for use in)
IT Semiconductor devices
(forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT Semiconductor device fabrication
(forming multilayer semiconductor structure on P-doped **germanium substrate** in)
IT Diffusion
Electric contacts
Passivation
(in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT Group VA element compounds
(phosphides; forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT Doping
(phosphorus; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT 75-24-1, Trimethyl aluminum 97-93-8, Triethyl aluminum, processes
(aluminum source; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in

solar cells)
IT 7723-14-0, Phosphorus, uses
(dopant; forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT 1115-99-7, Triethyl gallium 1445-79-0, Trimethyl gallium
(gallium source; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT 1303-00-0P, Gallium arsenide, processes **106312-00-9P**, Gallium indium phosphide 107102-89-6P, Aluminum gallium indium phosphide 107121-39-1P, Aluminum indium phosphide
(in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT 7440-38-2, Arsenic, processes
(in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT 923-34-2, Triethyl indium 3385-78-2, Trimethyl indium
(indium source; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)
IT **7440-56-4**, Germanium, processes
(passivated; in forming multilayer semiconductor structure on P-doped **germanium substrate** for use in **solar cells**)

L25 ANSWER 21 OF 34 HCA COPYRIGHT 2005 ACS on STN
133:166160 32.3% efficient triple junction GaInP2/GaAs/Ge concentrator **solar cells.** Lillington, D.; Cotal, H.; Ermer, J.; Friedman, D.; Moriarty, T.; Duda, A. (Sylmar, CA, 91342, USA). Proceedings of the Intersociety Energy Conversion Engineering Conference, 35th(Vol. 1), 516-521 (English) 2000. CODEN: PIECDE. ISSN: 0146-955X. Publisher: Society of Automotive Engineers.
AB This paper describes progress toward achieving high-efficiency, multijunction **solar cells** for cost effective application in terrestrial photovoltaic concentrator systems. Small area triple junction GaInP2/GaAs/Ge **solar cells** have been fabricated with an efficiency of >32% when measured at National Renewable Energy Lab. under an air-mass 1.5D spectrum at 47 suns concn. Small changes to the device design can achieve similar efficiencies at concn. ratios of .apprx.500 suns, resulting in cell costs of $0.5-0.6/W today, at prodn. vols. of .apprx.50 MW/yr. This makes them highly cost effective in existing concentrator systems, compared to flat plate technologies. The future development of new 1 eV materials for space cells, in conjunction with further redn. in **Ge wafer** costs, promises to achieve **solar cells** of >40% efficiency that cost $0.4/W or less at these

concn. ratios.
IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(development of high-efficiency triple junction gallium indium phosphide/gallium arsenide/germanium concentrator **solar cells**)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA
CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium gallium phosphide triple junction concentrator **solar cell**; gallium arsenide triple junction concentrator **solar cell**; germanium triple junction concentrator **solar cell**
IT **Solar cells**
(concentrator; development of high-efficiency triple junction gallium indium phosphide/gallium arsenide/germanium concentrator **solar cells**)
IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(development of high-efficiency triple junction gallium indium phosphide/gallium arsenide/germanium concentrator **solar cells**)

L25 ANSWER 22 OF 34 HCA COPYRIGHT 2005 ACS on STN
132:95654 Strain relaxation in III-V **solar cells** grown on **germanium substrates.** Goorsky, M. S.; Hess, R. R.; Moore, C. D. (Department of Materials Science and Engineering, University of California, Los Angeles, CA, 90095-2595, USA). Lattice Mismatched Thin Films, Proceedings of the International Workshop on Lattice-Mismatched and Heterovalent Thin Film Epitaxy, 1st, Castelvecchio Pascoli, Italy, Sept. 13-15, 1998, Meeting Date 1998, 73-80. Editor(s): Fitzgerald, Eugene A. Minerals, Metals & Materials Society: Warrendale, Pa. (English) 1999. CODEN: 68KRAT.
AB The materials properties of Group III-V tandem **solar**

cells grown on Ge were examd. using triple axis x-ray scattering techniques. First, the 5 .mu.m GaAs buffer layer was found to be relaxed by .apprxeq.85% with respect to the underlying **Ge substrate.** The extent of relaxation did not change with lattice direction and a tilt on the order of 60 arc sec exists at the interface. Based on first order comparison of the coeffs. of thermal expansion between the two materials, the GaAs layer is nearly fully relaxed at the growth temp. of about 700.degree. and becomes strained during cooling. Second, Al0.63Ga0.37As and InxGa1-xP (0.48 < XIn < 0.53) layers were detd. to be pseudomorphic with respect to the GaAs buffer layer and maintain the same miscut direction as the substrate. Anal. of these layers also shows that the std. interpretations used to det. lattice rotations and tilts for both strained and relaxed layers may be incorrect under certain circumstances.

IT **106312-00-9**, Gallium indium phosphide
(strain relaxation in Group III-V **solar cells** grown on **germanium substrates**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, Germanium, uses
(strain relaxation in Group III-V **solar cells** grown on **germanium substrates**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST **solar cell** Group III V strain relaxation;
germanium substrate solar cell
strain relaxation

IT Metalorganic vapor phase epitaxy
Tandem **solar cells**
(strain relaxation in Group III-V **solar cells** grown on **germanium substrates**)

IT Group IIIA element pnictides
(strain relaxation in Group III-V **solar cells** grown on **germanium substrates**)

IT 1303-00-0, Gallium arsenide, uses **106312-00-9**, Gallium

indium phosphide 106804-30-2, Aluminum gallium arsenide
al0.6ga0.4as
(strain relaxation in Group III-V **solar cells**
grown on **germanium substrates**)

IT **7440-56-4**, Germanium, uses
(strain relaxation in Group III-V **solar cells**
grown on **germanium substrates**)

L25 ANSWER 23 OF 34 HCA

132:4805 **Solar cell** having an integral monolithically grown bypass diode. Ho, Frank; Yeh, Milton Y.; Chu, Chaw-Long; Iles, Peter A. (Tecstar Power Systems, Inc., USA). PCT Int. Appl. WO 9962125 A1 19991202, 33 pp. DESIGNATED STATES: W: AE, AL, AM, AT, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ, DE, DE, DK, DK, EE, EE, ES, FI, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI; RW: AT, BE, BF, BJ, CF, CG, CH, CI, CM, CY, DE, DK, ES, FI, FR, GA, GB, GR, IE, IT, LU, MC, ML, MR, NE, NL, PT, SE, SN, TD, TG. (English). CODEN: PIXXD2. APPLICATION: WO 1999-US11171 19990519. PRIORITY: US 1998-PV87206 19980528.

AB The present invention is directed to systems and methods for protecting a **solar cell.** The **solar cell** includes first **solar cell** portion. The first **solar cell** portion includes at least one junction and at least one **solar cell** contact on a backside of the first **solar cell** portion. At least one bypass diode portion is epitaxially grown on the first **solar cell** portion. The bypass diode has at least one contact. An interconnect couples the **solar cell** contact to the diode contact.

IT **106312-00-9**, Gallium indium phosphide
(**solar cell** having integral monolithically
grown bypass diode)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate; solar cell** having
integral monolithically grown bypass diode)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC H01L031-042; H01L031-05; H01L031-06; H01L031-18; H01L027-142;
H01L023-62
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76
ST **solar cell** protection bypass diode
IT Diodes
(bypass; **solar cell** having integral
monolithically grown bypass diode)
IT **Solar cells**
Space vehicles
(**solar cell** having integral monolithically
grown bypass diode)
IT 1303-00-0, Gallium arsenide, uses 37382-15-3, Aluminum gallium
arsenide **106312-00-9**, Gallium indium phosphide
(**solar cell** having integral monolithically
grown bypass diode)
IT **7440-56-4**, **Germanium**, uses
(**substrate**; **solar cell** having
integral monolithically grown bypass diode)

L25 ANSWER 24 OF 34 HCA COPYRIGHT 2005 ACS on STN
131:274142 Development and characterization of high-efficiency
Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar
cells.** Karam, Nasser H.; King, Richard R.; Cavicchi, B.
Terence; Krut, Dimitri D.; Ermer, James H.; Haddad, Moran; Cai, Li;
Joslin, David E.; Takahashi, Mark; Eldredge, Jack W.; Nishikawa,
Warren T.; Lillington, David R.; Keyes, Brian M.; Ahrenkiel, Richard
K. (Spectrolab, Inc., Sylmar, CA, 91342, USA). IEEE Transactions on
Electron Devices, 46(10), 2116-2125 (English) 1999. CODEN: IETDAI.
ISSN: 0018-9383. Publisher: Institute of Electrical and Electronics
Engineers.
AB This paper describes recent progress in the characterization, anal.,
and development of high-efficiency, radiation-resistant
Ga0.5In0.5P/GaAs/Ge dual-junction (DJ) and triple-junction (TJ)
solar cells. DJ cells have rapidly transitioned
from the lab. to full-scale (325 kW/yr) prodn. at Spectrolab.
Performance data for >470,000 large-area (26.94 cm2), thin (140
.mu.m) DJ **solar cells** grown on low-cost,
high-strength **Ge substrates** are shown. Advances
in next-generation triple-junction Ga0.5In0.5P/GaAs/Ge cells with an
active Ge component cell are discussed, giving efficiencies up to
26.7% (21.65-cm2 area), air-mass 0, at 28.degree.. Final-to-initial
power ratios P/P0 of 0.83 were measured for these n-on-p DJ and TJ
cells after irradn. with 1015 1-MeV electrons/cm2. Time-resolved
photoluminescence measurements are applied to double

heterostructures grown with semiconductor layers and interfaces relevant to these multijunction **solar cells**, to characterize surface and bulk recombination and guide further device improvements. Dual- and triple-junction Ga0.5In0.5P/GaAs/Ge cells are compared to competing space photovoltaic technologies, and found to offer 60-75% more end-of-life power than high-efficiency Si cells at a nominal array temp. of 60.degree..

IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(development and characterization of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium phosphide junction **solar cell**; gallium arsenide germanium junction **solar cell**

IT **Solar cells**
(development and characterization of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(development and characterization of high-efficiency Ga0.5In0.5P/GaAs/Ge dual- and triple-junction **solar cells**)

L25 ANSWER 25 OF 34 HCA COPYRIGHT 2005 ACS on STN

130:354751 Method for fabrication of high-efficiency **solar cell.** Hou, Hong Q.; Reinhardt, Kitt C. (Sandia Corporation, USA). PCT Int. Appl. WO 9927587 A1 19990603, 46 pp. DESIGNATED STATES: W: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA,

UG, UZ, VN, YU, ZW, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM; RW: AT, BE, BF, BJ, CF, CG, CH, CI, CM, CY, DE, DK, ES, FI, FR, GA, GB, GR, IE, IT, LU, MC, ML, MR, NE, NL, PT, SE, SN, TD, TG. (English). CODEN: PIXXD2. APPLICATION: WO 1998-US25377 19981124. PRIORITY: US 1997-978658 19971126.

AB A high-efficiency 3- or 4-junction **solar cell** is disclosed with a theor. AM0 energy conversion efficiency of about 40%. The **solar cell** includes p-n junctions, formed from InGaAsN, GaAs and InGaAlP sepd. by n-p tunnel junctions. An optimal Ge p-n junction can be formed in the substrate upon which the other p-n junctions are grown. The bandgap energies for each p-n junction are tailored to provide substantially equal short-circuit currents for each p-n junction, thereby eliminating current bottlenecks and improving the overall energy conversion efficiency of the **solar cell.** Addnl., the use of an InGaAsN p-n junction overcomes super-bandgap energy losses that are present in conventional multi-junction **solar cells.** A method is also disclosed for fabricating the high-efficiency 3- or 4-junction **solar cell** by metal-org. chem. vapor deposition.

IT **106312-00-9**, Gallium indium phosphide
(method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate**; method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IC ICM H01L031-00

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST indium gallium arsenide nitride **solar cell**

IT Vapor deposition process
(metalorg.; method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

IT **Solar cells**

(method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

IT 12645-36-2, Gallium indium arsenide phosphide 37382-15-3, Aluminum gallium arsenide ((Al,Ga)As) **106312-00-9**, Gallium indium phosphide 107102-89-6, Aluminum gallium indium phosphide 107121-39-1, Aluminum indium phosphide 156739-92-3, Gallium indium arsenide nitride 225106-31-0, Aluminum gallium indium arsenide nitride
(method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

IT **7440-56-4**, **Germanium**, uses
(**substrate**; method for fabrication of high-efficiency 3- or 4-junction **solar cell**)

L25 ANSWER 26 OF 34 HCA COPYRIGHT 2005 ACS on STN
130:97938 **Solar cells** for the Rover on Mars.
Yamaguchi, Masafumi (Grad. Sch. Eng., Toyota Technol. Inst., Nagoya, 468-8511, Japan). Oyo Butsuri, 67(11), 1311-1314 (Japanese) 1998. CODEN: OYBSA9. ISSN: 0369-8009. Publisher: Oyo Butsuri Gakkai.

AB A review with 12 refs. GaAs **solar cells** fabricated on **Ge substrates** have been used for the Lander and Rover on Mars. Recently, the first satellite using **InGaP**/GaAs 2-junction **solar cells** has already been launched. In this paper, the characteristics and physics of **solar cells** grown on **Ge substrates** and properties of **solar cells** for the Rover on Mars are described. Moreover, future prospects of space **solar cells** are discussed.

CC 52-0 (Electrochemical, Radiational, and Thermal Energy Technology)
Section cross-reference(s): 76

ST review **solar cell** Lander Rover Mars; gallium arsenide phosphide **solar cell** review

IT Electric vehicles
Solar cells
Space vehicles
(**InGaP**/GaAs **solar cells** for the Rover on Mars)

IT 1303-00-0, Gallium arsenide, uses 60953-19-7, Gallium arsenide phosphide
(**InGaP**/GaAs **solar cells** for the Rover on Mars)

L25 ANSWER 27 OF 34 HCA COPYRIGHT 2005 ACS on STN
129:233067 Manufacturing and testing of GaAs/Ge **solar cells** using large capacity MOCVD equipments. Flores, C.; Smekens, G.; Timo, G.; Passoni, D.; Campesato, R.; De Villers, T. (CISE SpA, Segrate, 20090, Italy). European Space Agency, [Special Publication] SP, SP-416(Vol. 2, Fifth European Space Power Conference, 1998, Vol. 2), 523-525 (English) 1998. CODEN: ESPUD4.

ISSN: 0379-6566. Publisher: ESA Publications Division.

AB This paper describes the experience gained in manufg. GaAs/Ge space **solar cells** using large capacity metalorg. chem. vapor deposition (MOCVD) equipments, namely AIX2400 and AIX2600 gen.3. These equipments have been adapted to grow **solar cell** structures on large **Ge wafers** up to 115 mm in diam.

IT **7440-56-4**, Germanium, uses
(manuf. of gallium arsenide/germanium **solar cells** using large capacity metalorg. chem. vapor deposition app.)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

IT **106312-00-9**, Gallium indium phosphide
(manuf. of gallium indium phosphide/gallium arsenide/germanium cascade **solar cells** using large capacity metalorg. chem. vapor deposition app.)

RN 106312-00-9 HCA

CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST gallium arsenide germanium **solar cell** manuf

IT **Solar cells**
(cascade; manuf. of gallium indium phosphide/gallium arsenide/germanium cascade **solar cells** using large capacity metalorg. chem. vapor deposition app.)

IT **Solar cells**
(manuf. of gallium arsenide/germanium **solar cells** using large capacity metalorg. chem. vapor deposition app.)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses
(manuf. of gallium arsenide/germanium **solar cells** using large capacity metalorg. chem. vapor deposition app.)

IT **106312-00-9**, Gallium indium phosphide
(manuf. of gallium indium phosphide/gallium arsenide/germanium cascade **solar cells** using large capacity

metalorg. chem. vapor deposition app.)

L25 ANSWER 28 OF 34 HCA COPYRIGHT 2005 ACS on STN
128:324144 **Solar cells** with single crystal
substrates. Nakajima, Kazuo (Fujitsu Ltd., Japan). Jpn. Kokai
Tokkyo Koho JP 10135494 A2 19980522 Heisei, 9 pp. (Japanese).
CODEN: JKXXAF. APPLICATION: JP 1996-292563 19961105.
AB The **solar cells** have a compd. semiconductor
layer contg. at least a p-n junction on a single crystal Si1-xGex
substrate matching the lattice of the substrate. Preferably, the
substrate is Si0.02Ge0.98 and the compd. layer has a GaAs bottom
film on the substrate and an In0.5Ga0.5P top film, or the substrate
is Si0.92Ge0.08 and the compd. layer is GaP.
IT **12776-63-5**, Gallium indium phosphide (Ga0.5In0.5P)
(**solar cells** with single crystal
germanium silicon **substrates** and compd.
semiconductor layer having matching lattice)
RN 12776-63-5 HCA
CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

IC ICM H01L031-04
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST **solar cell** single cryst silicon germanium;
gallium phosphide silicon germanium **solar cell**;
gallium arsenide silicon germanium **solar cell**;
indium gallium phosphide **solar cell**
IT **Solar cells**
(**solar cells** with single crystal
germanium silicon **substrates** and compd.
semiconductor layer having matching lattice)
IT 1303-00-0, Gallium arsenide, uses 11148-23-5 12063-98-8, Gallium
phosphide, uses **12776-63-5**, Gallium indium phosphide
(Ga0.5In0.5P) 55000-69-6
(**solar cells** with single crystal
germanium silicon **substrates** and compd.
semiconductor layer having matching lattice)

L25 ANSWER 29 OF 34 HCA COPYRIGHT 2005 ACS on STN
127:164361 Manufacturing experience with GaInP2/GaAs/**Ge** solar
panels for space demonstration. Linder, E.B.; Hanley, J. P.
(TECSTAR INC., Applied Solar Division, City of Industry, CA, 91745,
USA). Conference Record of the IEEE Photovoltaic Specialists

Conference, 25th, 267-270 (English) 1996. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB TECSTAR has begun prodn. of dual-junction GalnP2/GaAs/Ge **solar cells** for space power application and has used these high-performance cells to manuf. several solar panels for crit. technol. demonstration. All cell and panel manufg. was performed at TECSTAR's existing facilities using std. processing techniques. Addnl., a panel coupon has been built for lab. evaluation. These important technol. demonstration activities are reported, including performance results.

IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide gainp2
(manufg. experience with GaInP2/GaAs/**Ge** solar **panels** for space demonstration)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST **solar cell** gallium indium phosphide; arsenide gallium **solar cell**; germanium **solar cell**; space demonstration **solar cell**

IT **Solar cells**
Space vehicles
(manufg. experience with GaInP2/GaAs/**Ge** solar **panels** for space demonstration)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide gainp2
(manufg. experience with GaInP2/GaAs/**Ge** solar **panels** for space demonstration)

L25 ANSWER 30 OF 34 HCA COPYRIGHT 2005 ACS on STN

124:321477 Large area GaInP2/GaAs/Ge multijunction **solar cells** for space applications. Chiang, P. K.; Krut, D. D.; Cavicchi, B. T.; Bertness, K. A.; Kurtz, Sarah R.; Olson, J. M. (Spectrolab Inc., Sylmar, CA, 91342, USA). Conference Record of the

IEEE Photovoltaic Specialists Conference, 24th(1994 IEEE First World Conference on Photovoltaic Energy Conversion, Vol. 2), 2120-3 (English) 1994. CODEN: CRCNDP. ISSN: 0160-8371. Publisher: Institute of Electrical and Electronics Engineers.

AB We report herein the demonstration of high efficiency GaInP2/GaAs **solar cells** on **germanium substrates**, and highly uniform cell results from a multiwafer MOVPE reactor. A peak efficiency of 24.2% (AM0, 28.degree.) has been achieved for dual-junctions grown on Ge. Further, the degree of MOVPE layer uniformity required for large area cells has been demonstrated with multiwafer growths on 3 in. diam. GaAs substrates. In addn. to this exptl. dual-junction result, we present modeling for the next step of this cell technol. - a triple junction GaInP2/GaAs/Ge cell.

IT **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (gainp2)
(large area GaInP2/GaAs/Ge multijunction **solar cells** for space applications)

RN 7440-56-4 HCA

CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 12776-63-5 HCA

CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0
In	1	7440-74-6
Ga	1	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)

ST **solar cell** multijunction space; gallium indium phosphide **solar cell** space

IT Photoelectric devices, solar
(multijunction; large area GaInP2/GaAs/Ge multijunction **solar cells** for space applications)

IT Epitaxy
(metalorg. vapor-phase, large area GaInP2/GaAs/Ge multijunction **solar cells** for space applications)

IT 1303-00-0, Gallium arsenide, uses **7440-56-4**, Germanium, uses **12776-63-5**, Gallium indium phosphide (gainp2)
(large area GaInP2/GaAs/Ge multijunction **solar cells** for space applications)

L25 ANSWER 31 OF 34 HCA

124:92517 The p/n InP **solar cells** on **Ge wafers.** Wojtczuk, Steven; Vernon, Stanley; Burke, Edward A. (Spire Corp., Bedford, MA, USA). NASA Conference Publication, 3278(Proceedings of the XIII Space Photovoltaic Research and Technology Conference, 1994), 91-8 (English) 1994. CODEN: NACPDX. ISSN: 0191-7811. Publisher: National Aeronautics and Space Administration.

AB InP p-on-n one-**sun solar cells** were epitaxially grown using a metalorg. chem. vapor deposition process on **Ge wafers.** The motivation for this work is to replace expensive InP wafers, which are fragile and must be thick and therefore heavy, with less expensive **Ge wafers**, which are stronger, allowing use of thinner, lighter wt. wafers. An intermediate InxGa1-xP grading layer starting as In0.49Ga0.51P at the GaAs-coated **Ge wafer surface** and ending as InP at the top of the grading layer (backside of the InP cell) was used to attempt to bend some of the threading dislocations generated by lattice-mismatch between the **Ge wafer** and InP cell so they would be harmlessly confined in this grading layer. The best InP/Ge cell was independently measured by NASA-Lewis with a one-sun 25.degree. AM0 efficiency of 9.1%, open-circuit voltage of 790 mV, fill-factor of 70%, and short-circuit photocurrent 22.6 mA/cm2. We believe this is the first published report of an InP cell grown on a **Ge wafer.**

IT **7440-56-4**, Germanium, uses **106312-00-9**, Gallium indium phosphide **106770-37-0**, Gallium indium phosphide Ga0.51In0.49P
(metalorg. chem. vapor deposited indium phosphide p-on-n one-**sun solar cells**)

RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

RN 106770-37-0 HCA
CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST indium phosphide **solar cell germanium wafer**
IT Photoelectric devices, solar
(metalorg. chem. vapor deposited indium phosphide p-on-n one-**sun solar cells**)
IT 1303-00-0, Gallium arsenide, uses
(**Ge wafer** coated with; metalorg. chem. vapor deposited indium phosphide p-on-n one-**sun solar cells**)
IT **7440-56-4**, Germanium, uses 22398-80-7, Indium phosphide, uses **106312-00-9**, Gallium indium phosphide **106770-37-0**, Gallium indium phosphide Ga0.51In0.49P
(metalorg. chem. vapor deposited indium phosphide p-on-n one-**sun solar cells**)

L25 ANSWER 32 OF 34 HCA COPYRIGHT 2005 ACS on STN
123:318703 U.S. advances in multi-junction **solar cells**/panels for space. Ho, F. F.; Yeh, Y. C. M. (Applied Solar Energy Corporation, City of Industry, CA, 91749, USA). European Space Agency, [Special Publication] ESA SP, ESA SP-369(Vol. 2, Proceedings of the European Space Power Conference, 1995, Vol. 2), 683-6 (English) 1995. CODEN: ESPUD4. ISSN: 0379-6566. Publisher: ESA Publications.
AB The prodn. status of cascade **solar cells** for space application is described. Based on the reported performance and evaluation of the user requirements, a monolithic, two-terminal cell comprising GaInP2/GaAs grown on **Ge substrate** was selected. Current performance data is presented, and the plans to incorporate high-efficiency, space-qualified cascade cells into the present prodn. mix of Si and GaAs cells are discussed.
IT **12776-63-5**, Gallium indium phosphide (GaInP2)
(prodn. status of monolithic, two-terminal gallium indium phosphide/gallium arsenide cascade **solar cells** for space application)
RN 12776-63-5 HCA
CN Gallium indium phosphide (GaInP2) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	2	7723-14-0

In	1	7440-74-6
Ga	1	7440-55-3

IT **7440-56-4**, **Germanium**, uses
(**substrate**; prodn. status of monolithic, two-terminal cascade **solar cells** of gallium indium phosphide/gallium arsenide grown on)
RN 7440-56-4 HCA
CN Germanium (7CI, 8CI, 9CI) (CA INDEX NAME)

Ge

CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST **solar cell** cascade prodn space; indium gallium phosphide cascade **solar cell**; gallium arsenide cascade **solar cell**
IT Photoelectric devices, solar
(cascade, prodn. status of monolithic, two-terminal gallium indium phosphide/gallium arsenide cascade **solar cells** for space application)
IT 1303-00-0, Gallium arsenide, uses **12776-63-5**, Gallium indium phosphide (GaInP2)
(prodn. status of monolithic, two-terminal gallium indium phosphide/gallium arsenide cascade **solar cells** for space application)
IT **7440-56-4**, **Germanium**, uses
(**substrate**; prodn. status of monolithic, two-terminal cascade **solar cells** of gallium indium phosphide/gallium arsenide grown on)

L25 ANSWER 33 OF 34 HCA
122:318717 High-efficiency multijunction **solar cell.**
Ho, Frank F.; Yeh, Milton Y. (Applied Solar Energy Corp., USA). U.S. US 5405453 A 19950411, 9 pp. (English). CODEN: USXXAM. APPLICATION: US 1993-149052 19931108.
AB The cell comprises a **Ge substrate** having a front and a back surface; a back metal contact on the back surface of the substrate; a 1st semiconductor cell comprising a GaAs p-n junction with the n-GaAs layer formed on the front surface of the substrate, and a p-(Al,Ga)As window layer on the p-GaAs layer; a tunnel diode comprising a GaAs p+-n+ junction with the p+-GaAs layer formed on the p-(Al,Ga)As window layer; and a 2nd semiconductor cell comprising a (Ga,In)P p-n junction with the n(Ga,In)P layer formed on the n+-GaAs layer of the tunnel diode, a p-(Al,In)P window or contact layer formed on the p-(Ga,In)P layer, metal grid lines contacting either the p-(Ga,In)P layer or the p-(Al,In)P layer, and .gtoreq.1 antireflection coating layer covering the (Al,In)P layer. The cascade cell of the invention permits achieving actual

efficiencies of >23%.
IT **106312-00-9**, Gallium indium phosphide
(high-efficiency multijunction **solar cell**
contg. layer of)
RN 106312-00-9 HCA
CN Gallium indium phosphide ((Ga,In)P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number
P	1	7723-14-0
In	0 - 1	7440-74-6
Ga	0 - 1	7440-55-3

IC ICM H01L031-068
INCL 136249000
CC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
ST gallium arsenide cascade **solar cell**; aluminum
gallium arsenide **solar cell**; indium gallium
phosphide **solar cell**; phosphide aluminum indium
solar cell
IT 1303-00-0, Gallium arsenide, uses 37382-15-3, Aluminum gallium
arsenide ((Al,Ga)As) **106312-00-9**, Gallium indium phosphide
107121-39-1, Aluminum indium phosphide
(high-efficiency multijunction **solar cell**
contg. layer of)

L25 ANSWER 34 OF 34 HCA COPYRIGHT 2005 ACS on STN
122:60037 High-efficiency tandem **solar cells** on
single- and poly-crystalline substrates. Hutchby, J. A.; Timmons,
M. L.; Venkatasubramanian, R.; Sharps, P. R.; Whisnant, R. A.
(Center for Semiconductor Research, Research Triangle Institute,
Research Triangle Park, NC, 27709, USA). Solar Energy Materials and
Solar Cells, 35(1-4), 9-24 (English) 1994. CODEN: SEMCEQ. ISSN:
0927-0248. Publisher: Elsevier.
AB A review with 28 refs. This paper will review and assess the
current status of the development of tandem **solar
cells** for space and terrestrial applications. We will also
introduce and present results on a new In0.49Ga0.51P/GaAs tandem
cell grown and fabricated on a low-cost, polycryst. **Ge
substrate.**
IT **106770-37-0**, Gallium indium phosphide (Ga0.51In0.49P)
(high-efficiency tandem **solar cells** on
single- and poly-cryst. substrates)
RN 106770-37-0 HCA
CN Gallium indium phosphide (Ga0.51In0.49P) (9CI) (CA INDEX NAME)

Component	Ratio	Component Registry Number

P	1	7723-14-0
In	0.49	7440-74-6
Ga	0.51	7440-55-3

CC 52-0 (Electrochemical, Radiational, and Thermal Energy Technology)

ST review tandem **solar cell**; indium gallium phosphide **solar cell** review; arsenide gallium tandem **solar cell** review

IT Photoelectric devices, solar
(high-efficiency tandem **solar cells** on single- and poly-cryst. substrates)

IT 1303-00-0, Gallium arsenide, uses **106770-37-0**, Gallium indium phosphide (Ga0.51In0.49P)
(high-efficiency tandem **solar cells** on single- and poly-cryst. substrates)